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A Comparative Life Cycle Assessment for Utilising Laminated Veneer Bamboo as a Primary Structural Material in High-Rise Residential Buildings

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REVISED

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Abstract

In a time when construction is ranked as one of the world's least sustainable industries consuming about half of the world's non-renewable resources (Hinson, 2012), it is important to develop and advance the methods and means by which we select and use building materials and how we design, engineer and construct our architecture.

This research aimed to evaluate a method for utilising laminated veneer bamboo (LVB) as a primary structural material in high-rise residential buildings and evaluate the environmental potential of LVB through a comparative life cycle analysis (LCA). The process of life cycle analysis was completed through the development of a Revit® model and utilising the Tally® life cycle assessment application. A comparative LCA, in particular the global warming potential between laminated veneer bamboo and cross laminated timber, was conducted using a case study model of Stadthaus, Murray Grove, London. This 9-story residential building is constructed using cross laminated timber (CLT) as the primary building material and provides a highly appropriate comparison for this research on the selection of laminated veneer bamboo as an alternative structural material to CLT.

The structural aspect of this study aimed to evaluate the mechanical properties of a laminated veneer bamboo sheet product. The capabilities of LVB were reviewed by means of a comparative analysis against timber sheet products (OSB, Plywood). By utilising the strength of engineered bamboo efficiently, a diaphragm panel system was designed and tested as part of the LCA study as an alternative to the CLT panels that were used in the construction of Stadthaus at Murray Grove, London.

The literature review and primary research present the environmental value of selecting bamboo as an alternative building material to steel, concrete and engineered timber, three of the most widely used primary structural materials in building projects today. These primary building

materials, in particular concrete and steel, are energy intensive in their production[1] and application and have a high global warming potential when compared to 'green' construction materials, for instance, timber and bamboo.

The hypothesis is that engineered bamboo, through its potential to be efficiently designed for use in small and large scale buildings, has the potential to be an alternative, environmentally friendly, primary structural material. Bamboo is, based on its properties, an underutilised resource. Ongoing research and previous studies in Europe and Asia (Chung & Yu, 2002; Li, Zhang, Huang, & Deeks, 2013; C.S. Verma & Chariar, 2012) have shown that engineered bamboo can match the strengths of steel and in some cases far exceed those of engineered timber products. These studies show that there is a potential to utilise engineered bamboo for use as a primary structural material.

[1] The author notes that there is a case to be made for the use of concrete and steel in specific building projects. It is also noted that there is a more environmentally friendly alternatives to the cement used in concrete. In particular the development of 'Ecocem' and other supplementary cementing materials, as an alternative to Portland cement, present a promising future in reducing the carbon footprint of concrete buildings. However, at the current time timber and bamboo as naturally occurring materials still have the benefit of sequestering and storing CO_2 during their growth something which concrete and steel fail to achieve as they are not naturally occurring materials.

Declaration

I certify that this thesis which I now submit for examination for the award of MPhil Masters by Research, is entirely my own work and has not been taken from the work of others, save and to the extent that such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the regulations for postgraduate study by research of the Dublin Institute of Technology and has not been submitted in whole or in part for another award in any other third level institution.

The work reported on in this thesis conforms to the principles and requirements of the DIT's guidelines for ethics in research.

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Candidate

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Contents

Abbreviations List

LCA – Life Cycle Analysis

BRE – Building Research Establishment

FSC – Forest Stewardship Council

CO_2 – Carbon Dioxide

O_2 – Oxygen

cm - Centimetres

m – Meters

m^2 – Square Meters

m^3 – Cubic Meters

T - Metric Tonnes

LVL – Laminated veneer lumber

LVB – Laminated veneer bamboo

CLT – Cross Laminated timber

SWB – Strand Woven Bamboo

Glulam – Glue Laminated timber

EPA - Environmental Protection Agency

ASTM - American Society for Testing and Materials (Now ASTM International)

ISO – International Standards Organisation

GWP – Global Warming Potential

CO_2e - Carbon dioxide Equivalent

Eco-Cost – A measure to express the amount of environmental burden a product or system has. Represented in terms of Euros per kilogram i.e. €/Kg

U.K. – United Kingdom

U.S. – United States (of America)

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Research Aims

The aim of this research project is to establish, through a structural comparison review and comparative life cycle analysis (LCA), the overall contribution that laminated veneer bamboo (LVB) has to global warming potential against that of cross laminated timber (CLT). This study also aims to establish if engineered bamboo is a feasible alternative construction material for use in high density urban housing in a European context.

Objectives

The project aims to achieve the following objectives:

1. Collate and critically analysis and data from the field of bamboo and laminated veneer bamboo.
2. Establish through structural data comparisons the potential for engineered bamboo products to be implemented into high rise construction.
3. Research the embodied carbon of LVB and CLT and apply this to the Life Cycle test results
4. Conduct a comparative Life Cycle Analysis (LCA) on laminated veneer bamboo (LVB) and cross laminated timber (CLT) to assess the global warming potential of both.

1.0 Introduction

In a time when construction is ranked as one of the world's least sustainable industries consuming about half of the world's non-renewable resources (Hinson, 2012), it is important to develop and advance the methods and the means by which we select building materials and design, engineer and construct our architecture. Bamboo is a naturally occurring material located mainly in tropical and subtropical regions of the world, particularly Asia and South America. This **grass** has been used in construction for millennia predominantly in countries where it grows rapidly and in abundance for uses such as huts for living as well as structures such as scaffolding for building. (S. C. Lakkad, 1981) Bamboo also has other qualities at different stages of its life cycle as described by Cassandra Adams (1998) in her research and notes on Bamboo Architecture and Construction with Oscar Hidalgo (1998). These aspects of bamboo are listed below:

- Less than 30 days - Utilised for food and cooking purposes
- 6-9 months - good for basket weaving
- 2-3 years – used for bamboo boards or laminations
- 3-6 years – used for construction purposes (Raw application)
- Greater than 6 years - bamboo gradually loses strength up to 12 years old. (Adams, 1998)

Bamboo, like timber, is an environmentally friendly, sustainable and 'green' construction material. Bamboo is an efficient renewable resource due to its rapid growth. Established bamboo species, for instance those of the Phyllostachys (Moso) species native to Asia; the *Phyllostachys Pubescenes*, *Phyllostachys Bambusoides* and *Phyllostachys atrovaginata* and the Guadua species native to the Neotropic region of South America particularly *Guadua Angustifolia*, can grow 15-18cm per day and can reach a full height of 40 – 50 feet (12-15 meters) within one growth cycle of 4-6 months, in perfect conditions. (Albermani, G.Y. Goh, & Chan, 2007) This is beneficial in a number of ways, but most importantly it means that a bamboo plantation can be harvested every 3-6 years, again in perfect conditions on the fourth year of growth. As suggested by Adams (1998), if the potential harvesting of bamboo for board or laminated and engineered products is at year 2-3 of the growth cycle, the growth cycle of raw bamboo for construction applications of 3-6 years is further reduced when utilised in an engineered manner. Compared to the growth of some timber species such as spruce (Sitka Spruce) which has an average growth cycle of 20-45 years (Department of Agriculture, 2016) and birch at an average growth cycle of 20-40 years, it can be seen that bamboo can be harvested 80% faster than that of timber given the right circumstances. (Albermani, G.Y. Goh, & Chan, 2007)

The use of bamboo in structures and mainstream architecture has been hindered by a lack of knowledge and a uniformity of materials. The lack of uniformity that bamboo possesses, mainly its cylindrical shape, does not lend itself particularly well to typical building methods. To solve the issue of uniformity bamboo clums (poles) can be cut down into strips or chipped and laminated together with an adhesive to provide consistent strength, dimensional stability and uniformity that can potentially lead to bamboo being utilised as a primary building material in high rise buildings.

1.1 Hypothesis

This study will look at the process of selecting and applying engineered bamboo or laminated veneer bamboo (LVB) into architectural designs and will evaluate its environmental properties through a Life Cycle Assessment (LCA), with particular interest in the global warming potential (GWP) of the material and mechanical properties against a commonly used construction materials including Cross Laminated Timber (CLT).

It is the author’s hypothesis that LVB has the ability to be integrated into architectural designs, such as mid to high rise residential accommodation as a sustainable, environmentally friendly construction material. Given its natural capabilities, particularly rapid growth and high carbon sequestration it is a material that is easily attainable and environmentally friendly.

1.2 INBAR

The establishment of INBAR, the International Network for Bamboo and Rattan, contributed to the rejuvenation of bamboo and begun a wide array of studies on the potential use of bamboo not only for construction purposes but a variety of other subject matters including economic development and agricultural projects. INBAR aims are simple; utilise bamboo and rattan to improve livelihoods and promote it as a naturally occurring sustainable material.

"The International Network for Bamboo and Rattan is an intergovernmental organisation dedicated to improving the livelihoods of the poor producers and users of bamboo and rattan, within the context of a sustainable natural environment". (INBAR, 2014)

1.3 Growth of Bamboo and Potential for European Growth

Bamboo is a perennial grass[2] (Toro Company, 2013) found in most tropical countries. It is a rapidly growing grass and considered a Rhizomes plant, a continuously growing horizontal underground stem that puts out lateral shoots and adventitious roots at intervals. (Britannica, 2016)

Each stem (culm) grows out of a net like root system and reaches its total height after only one year. Shortly after the lignin[3] starts to become more rigid and woody by depositing in cell walls "*and in the next 6-8 years it gains hardness and strength because of the silification of the outer tube wall. So bamboo can also be titled as a lignifying giant grass"(Rottke, 2016)*. The structure of a bamboo culm comprises of nodes, a solid diaphragm between culm walls, which separate the bamboo shoot into multiple segments known as internodes. The image below (Figure 1) shows a microscopic image of a cross section of a bamboo culm extracted from a dissertation on the performance of bamboo structural components by Michael J. Richard (2013).

[2] grasses that persist year after year, given the right conditions
[3] a complex organic polymer deposited in the cell walls of many plants, making them rigid and woody

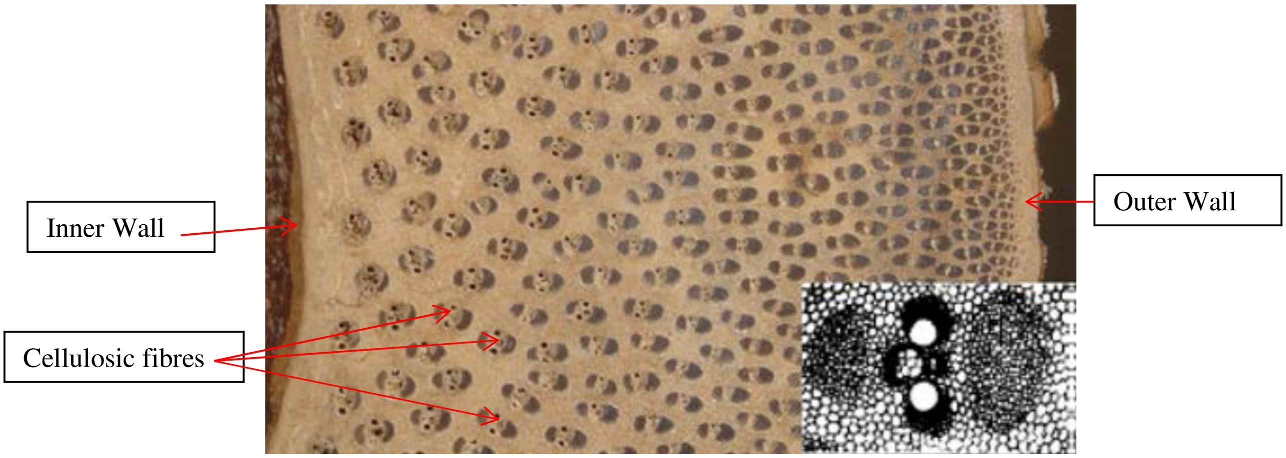


Figure 1: Microscopic view of bamboo vascular bundle (Janssen, 1981; Richard, 2008)

Here the distribution of cellulosic fibres can be seen from the inner region to the outer region of the bamboo culm wall. The cellulosic fibres are oriented parallel to the culm's longitudinal axis embedded in a lignin matrix (Richard, 2013). The bamboo micro structure has evolved to adapt to loading conditions in nature. The density of cellulosic fibres increases from the inner wall to the outer wall resulting in a 100% difference in fibres at the outer wall compared to those at the inner wall. This evolution results in a shoot that is capable of sustaining its own self-weight and the lateral loading effects of wind. (Shigeyasu, 2001)

It takes roughly three years for a bamboo shoot to fully mature. At this point the shoot will have reached a final height of up to 20-25meters in some cases and will have a diameter, in certain instances, of up to 18cm. The larger diameter in bamboo culms and height is particular to the species specifically *Guadua Angustifolia* and the area in which bamboo is predominantly grown, Asia and South America. It can be seen further down in this section that growth will diminish by 60-70% in cooler, wetter climates and in fact will not prosper in larger scale plantations that would be required for environmental and economic advantages when it comes to the engineered solution which is being studied.

Having considered and researched the options, the species that could have the potential to grow best in the European climate and in particular Ireland and the UK is the Phyllostachys species. This species was selected by a process of literature review as well as communications with leading experts in the growth of bamboo in European climates from The Kew Royal Botanical Gardens. There is a large body of research and further study to be conducted in relation to the growth and prosper of bamboo plantations in Europe. However, in particular the following three species show promise of satisfactory growth for re-engineering purposes in European climates:

I. Phyllostachys Pubescens,
II. Phyllostachys Bambusoides,
III. Phyllostachys atrovaginata formally "Phyllostachys congest"

Each of the species has shown potential to be cultivated in Europe (particularly in the South of Europe/the Mediterranean). For example the Phyllostachys atrovaginata sub-species has adapted over the years to deal with growing in wet soils. The sub-species has developed a means to drain water from its roots through air canals in the rhizomes and which are an adaptation for growing in wetter soils. (Garden, 2008)

Plantations growing for thirty years, and studies by Teagasc in Oak Park, Carlow, Ireland, show that bamboo has the potential to grow in Ireland and Europe. However, this potential shows dramatic reduction in the amount of biomass produced when compared to that of Asia and South America. In the Bamboo gardens at Kew Royal Botanical Gardens the best performing sub-specie of the Phyllostachys family is the "Phyllostachys atrovaginata" formally "Phyllostachys congest" which when fully matured reaches a total diameter of 4cm with the other two species Phyllostachys Pubescens and Phyllostachys Bambusoides only maturing to an average diameter of between 1-3cm. Total height of the stems is also reduced due to the cooler climate in the UK. Stems only reach a final height of 2-4m thus further reducing the biomass when comparing it to more tropical climates. The suggestion of the experts at Kew Royal Botanical Gardens was that the climate of the Mediterranean would be better suited for bamboo cultivation and larger scale plantations which could not be achieved in the harsher cooler climate of Ireland and the UK. By relocating the growth of bamboo to this area a higher yield per growth cycle can be achieved due to larger bamboo stems being created in a more advantageous climate. The stems in this climate could grow up to 10cm in diameter and up to 10-12m in height when compared to that of the Irish and UK climate which has the potential to achieve only 1-3cm in diameter and 3-4m high stems. (Information based on correspondence with Raymond Townsend bamboo expert at Kew Gardens (February 2014))

Infrastructure could potentially solve the issue of climatic conditions. The Botanic Gardens at Glasnevin, Dublin 9, Ireland, utilises large greenhouses to cultivate bamboo. The implementation of large greenhouses could provide climatic conditions to grow bamboo in any location around the world where it cannot be easily cultivated. This point was also confirmed by R. Townsend at Kew Gardens where they cultivate tropical bamboo species in a greenhouse environment. However, this could present an array of other embodied carbon and environmental issues and further research in this area is needed.

With the growth of bamboo in Europe hindered by climactic conditions the only option is to source bamboo and bamboo products from areas of the world where it can be cultivated and produced at a rapid pace. China, India and Brazil are major contributors to bamboo growth and cultivate and produce about 60-80% of the world's bamboo stock. (Dixon & Gibson, 2014; United Nations, 2013) With this in mind it makes for a building material which is readily available and quickly renewable and, depending on the use of the material, potentially carbon-zero after a few years an aspect which will be researched and reviewed as part of this study.

1.4 Environmental Design and Sustainability

Sustainability is based on a simple principle: *"Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, which permits fulfilling the social, economic and other requirements of present and future generations." (USEPA, 2015)*

According to the UN there is a projected rise in population of 1.3 to 3.5 billion by 2050. The significant rise in population will present major challenges. However, it could be the key to a sustainable future. By creating city developments or re-designing our current cities and cityscapes for pedestrians, cyclists and means of efficient public transport and not for cars or heavy goods vehicles, there may be a future for the growing population in cities designed specifically for them and their needs. These ideas present issues for planners, architects and engineers on how to facilitate a rapidly growing population. Building structures that use high energy, high carbon footprint materials to facilitate billions of people could have a detrimental effect on the environment.

A more efficient way to construct buildings utilising natural materials needs to be continually explored to minimise this risk. Engineered Bamboo has shown potential to be an environmentally friendly future alternative to concrete and steel for high density living. (De Flander & Rovers, 2009; Dongwei Yu, 2011)

A study conducted by Katleen De Flander and Ronald Rover (2009) at the Urban Environment Group, Wageningen University, Wageningen, The Netherlands, addressed the ongoing issue of energy consumption, vast resource consumption and the ever-growing environmental consequences of the built environment. With this as the base principle for the research the author(s) researched the potential of bamboo (Guadua) to produce one bamboo house per hectare of raw material every year (De Flander & Rovers, 2009).

The aim of this paper was to contribute to a real shift in resource management by focussing on the *'high-brow'*, modern use of bamboo for construction products. Therefore its main objective was to demonstrate the global potential of bamboo as a modern construction material. Its intent was to show that bamboo products can serve as an alternative to other materials such as brick, concrete and metal and as a direct competitor for hardwood products in daily building practice.

The fundamental goal of the research by De Flander et al (2009) was to promote the use of this fast-growing, renewable resource and transfer it out of its current experimental and special interest status and into mainstream use. This was accomplished by focussing on *‘high-tech’* products manufactured from bamboo and processed for easy use to meeting modern building standards. Comparable with the development of wood-based construction, bamboo needs to go through a similar process of professionalization, one which has seen a rise in recent years through the research and development of engineered bamboo products.

The house designed for this piece of research was a two story family house similar in size to a 3 bedroom semi-detached house (175m^2).

From this research it can be seen that bamboo has the potential to be used as a more sustainable alternative to modern construction methods i.e. block, brick, concrete, steel and timber. In regards to timber construction (the closest comparable building method) one can derive that a wood plantation with an average wood recovery of 142 m3/ha and 40 years of rotation age can provide material to construct 10 reference houses every 40 years, which is an average of one house every 4 years. (De Flander & Rovers, 2009)

It can be derived from the research that bamboo produces enough material in one hectare to construct one house every year. De Flander et al (2009) argue:

“The fact that a bamboo forest can be (partially) harvested every year, bamboo has a great advantage in yearly yield per forest area compared to wood.”

Cultivating bamboo in this manner presents further challenges of ecological destruction. Bamboo plantations need to be protected from over cultivation. Bamboo has been part of the Forest Stewardship Council (FSC) since 2004. (Moso, 2016a) However, FSC certified raw bamboo is still rare. In order to promote and develop a case for bamboo as a sustainable material a similar process to the management of timber forests must be introduced for bamboo plantations. Although bamboo has the advantage of being cut at the base during cultivation, resulting in the ability to grow again immediately, promoting a process of planting more bamboo as the material is extracted is fundamental and will have major benefits on the environmental impact of bamboo.

Furthermore, by promoting bamboo in such a way, like has been done in some developing areas of the world in the past decade, it has proven to be a catalyst to providing stability and consistent income to areas struggling with poverty (Renard & Lamballe, 2009). In the Thanh Hao Province, Vietnam, between 2004 and 2006, the total bamboo sector size grew from US$ 11 to US$ 15 million. The farm gate price for bamboo increased from US$11.7 to US$14.1/ton, and brought 21,000 people from "bamboo households" out of poverty. Mekong Bamboo's ultimate goal is to take more than 350,000 people out of poverty in the Mekong region of Vietnam by 2020 (Nguyen, 2010).

2.0 Literature Review

2.1 Product Manufacture

2.1.1 Laminated veneer bamboo (LVB)

Laminated veneer bamboo (LVB) is a product that uses multiple thin strips of bamboo combined with an adhesive to form a board or sheet product. Manufactured by Glubam, Moso and Lamboo© Inc. to name but a few it typically consists of 3, 5, 7, and 9 layers laminated veneer bamboo is manufactured in a similar way to OSB or Plywood. A series of thin strips of bamboo are laminated together in alternating 90 degree angles for each layer.

The production of LVB can be divided into the following steps:

(1) Slicing of bamboo poles longitudinally to create strips of bamboo. Strips are produced by feeding culms through a splitter machine that cuts the bamboo culm into slender strips.

(2) Surfaces of the strips are scraped and planed to remove wax and silica as well as to create rectangular cross sections.

(3) Strips are left to air-dry at room temperature for one week after they are cut.

(4) Air-dried strips are then immersed in a boron solution and left to dry in the sun until their moisture content reach 12%.

(5) Adhesive is applied to the strips that are then neatly arranged next to and on top of one another to create the final product.

(6) Bamboo sheets are produced by placing bamboo strips side-by-side and edge-gluing them using tannin resorcinol formaldehyde (TRF) (Mahdavi, Clouston, & Arwade, 2012)

Figure 2 on the page over shows a graphical breakdown of the process.

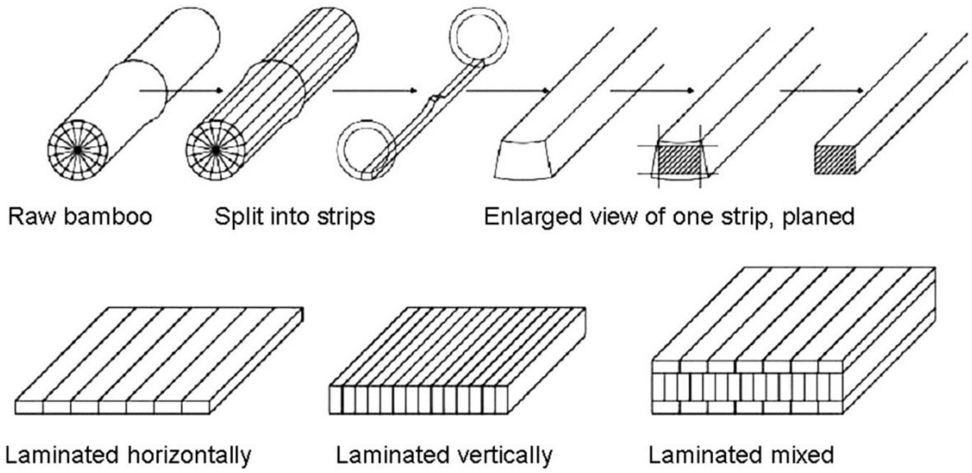


Figure 2: Manufacture process of Laminated Veneer Bamboo (Mahdavi, Clouston, & Arwade, 2011; Rittironkand & Elnieiri, 2015)

2.1.1.1 Life Cycle Material

As part of the life cycle assessment, and due to limitations in the datasets, laminated bamboo plank flooring is selected to calculate the global warming potential (GWP) of the LVB design option in comparison to a CLT design option. The manufacturing process of bamboo flooring follows a near identical path to that of laminated veneer bamboo. The exception is that the final quality of bamboo flooring will be of a much higher standard than the finish of LVB for construction purposes.

The final stages of sanding, coating and polishing will not be required for laminated veneer bamboo. This being said the process up until the finish is applied is identical and due to selecting Bamboo flooring in the LCA this may result in a minor disadvantage towards LVB resulting in a slightly higher GWP than is actually the case.

The process for bamboo flooring can be seen in figure 3 and 4 on the page over.

Figure 3: Manufacturing process for Bamboo plank Flooring. (Zhuhong, 2016)

Figure 4: Finishing Process for Bamboo Plank Flooring (Zhuhong 2016)

Figure 5: Laminated veneer bamboo ply board (Lamboo, 2014)

Figure 6: Laminated veneer bamboo (Moso, 2016b)

2.1.2 Cross laminated timber (Case study Stadthaus, Murray Grove)

Cross-laminated timber (CLT) is a mass wood based product, developed in Switzerland in the early 1990s, designed for increased dimensional stability and strength in framing systems. CLT is an engineered wood panel typically consisting of three, five, or seven layers of dimension lumber oriented at right angles to one another and then glued to form structural panels with exceptional strength, dimensional stability and rigidity (reThink, 2015).

Developed in a similar way to Glulam, a process of laminating timber strips in one direction and into single layer panels, cross laminated timber uses the single layer panels and laminates them into a multi-layer panel typically at right angles to one another. The production of CLT can be divided into the following steps:

(1) Kiln drying of milled timber boards
(2) Strength or stiffness grading,
(3) Removal of growth deficiencies large knots, cracks etc. which do not meet the requirements of the strength class and finger jointing of the residual board segments to endless lamellas,
(4) division and cutting of lamellas,

(5) (optional) adhesive bonding of lamellas to single-layer panels,

(6) Assembling and adhesive bonding of lamellas or single-layer panels to CLT, and

(7) Cutting and joining to structural elements (customizing).

Currently, CLT is manufactured using fast growing (20-30years) softwood species. As presented by Brandner (2013) *"The main species used in CLT is Norway spruce (Picea abies) in assortment with a small amount of White fir (Abies alba). Furthermore, softwood species such as Scots pine (Pinus sylvestris), European larch (Larix decidua), Douglas fir (Pseudotsuga menziesii) and Swiss stone pine (Pinus cembra) are made use of, whereby the last mentioned species are primary for CLT of high appearance quality and thus are used for the top layers"*

The manufacturing process can be seen in the graphic in figure 7 below.

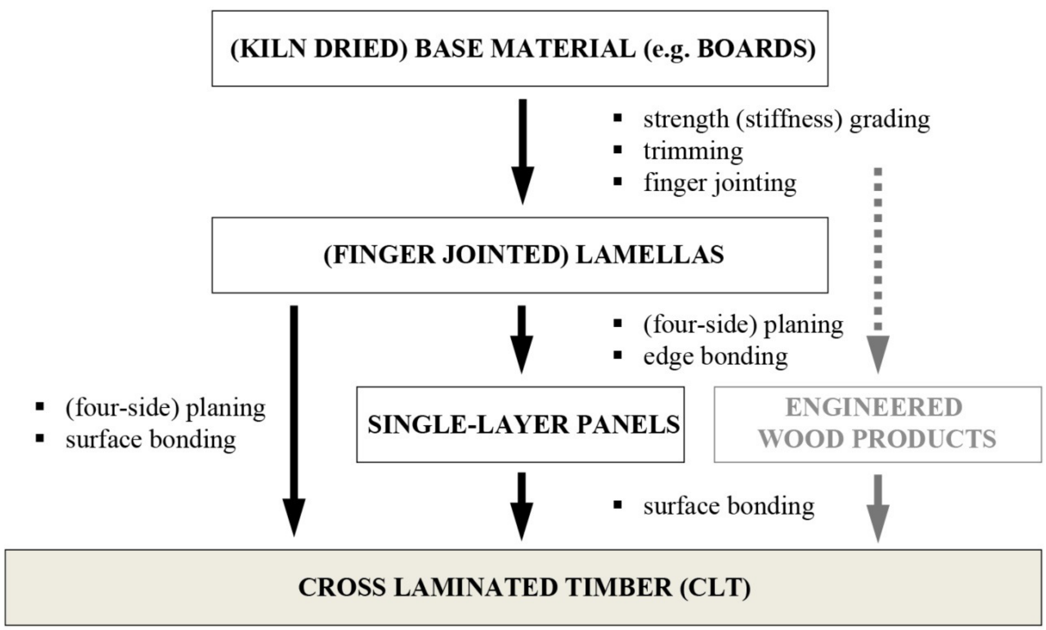


Figure 7: Cross Laminated Timber (CLT) manufacturing process (Brandner, 2013)

2.2 Economic Issues

2.2.1 The Potential for Bamboo Buildings in the West

In recent years, innovators have established new ways to promote and implement the use of bamboo in buildings. Advancements in technology allowed for LVB (laminated veneer bamboo), Plybamboo and strand woven bamboo to be manufactured giving designers the base to utilise these engineered bamboo products as they would timber technology but with a new faster growing, higher yielding, and more stable and stronger material (Lamboo, 2014). (GluBam, 2014) Unlike timber technology however, new standards need to be established for this material due to the different characteristics and mechanical properties. Bamboo is considered a grass not a wood and because of this the mechanical characteristics function differently and thus cannot be considered under the same criteria. Some of these standards for testing have been established in the US by ASTM (American Society for Testing and Materials) and these show great progress in establishing bamboo as an internationally recognised and tested building material.

With these standards set up for bamboo and with a growing interest in the testing of engineered bamboo by researchers, the scope for the potential use of bamboo in architectural designs, in this new engineered form, is advancing. The benefits of the selection of LVB over other energy intensive materials, i.e. concrete and steel, could have major effects on the way we approach design and how we think about the effect a design may have on its environment.

A big obstacle with bamboo buildings in Western Europe is a question of eco-cost and environmental burden. The matter that needs particular consideration is the transportation of raw material from areas where it is more prominent i.e. Asia and South America. [4]

[4] See Life cycle assessment chapter Section 7.0 for full analysis of transportation issue and High seas, High Stakes Critical review in Appendix

A study by Joost Vogtländer, Pablo van der Lugt and Han Brezet (Joost Vogtländer, 2010) shows:

"The bamboo stem is a sustainable solution for local applications. The transport distance to Europe, however, is the main hurdle in terms of environmental impact. For Europe, local species are more sustainable."

This then presents the question of can we grow the appropriate species in Europe thus reducing this environmental burden. This aspect is covered in the chapter on growth and gives an in depth scope of the potential growth in Europe.

Following on from this J. Vogtländer et al argue that;

B. Industrial bamboo materials in Europe in the form of Plybamboo and SWB (Strand Woven Bamboo), score well compared to FSC hardwood in terms of eco-costs as well as yield.

Industrial bamboo members could be beneficial by utilising the raw material and manufacturing engineered bamboo products near a plantation and then transporting in bulk to Western Europe. However, this only applies if the desired timber equivalent is from FSC forests which generally reside in tropical climates. Woods such as Mahogany and cherry would be under consideration in this case.

J. Vogtländer et al also argue that;

C. Second grade bamboo products, like MDF and chipboard from bamboo are a good solution for local applications. However, they cannot compete in Europe with the European second grade products from European softwood.

This presents a similar question of point; can we grow the appropriate species in Europe (see Bamboo growth chapter section 1.3) thus reducing this environmental burden.

D. The annual yield of bamboo, in combination with its durable root structure, is its big advantage. In terms of land-use, bamboo seems to be one of the promising solutions in the required shift towards renewable materials.

Finally a question that needs to be considered is how the eco-cost and environmental footprint compares to current popular building materials i.e. Timber steel and concrete. If the eco-cost is still lower after transportation or if it can be cultivated locally (1400Km Radius) (Joost Vogtländer, 2010) the logical step would be a move to adopt this material for future applicable building projects in Europe.

2.2.2 International Trade of bamboo and Rattan 2012

In a recent publication by INBAR (The International Network for Bamboo and Rattan), Director Hans Friederich compiled data from seven regions on the import and export of bamboo and rattan between 1992-2012, a 20 year period. The report studied the trade of bamboo from raw materials to the import and export of furniture and industrialised bamboo products like flooring and bamboo plywood. From this report, as previously stated, Asia is the main source of bamboo products, particularly in the export of materials. The export of bamboo and rattan products in Asia, in 2012, accounted for over $1.5billion USD (US Dollars) or 85% of the global export value. This was followed by Europe with a holding of 12% of the global export market in 2012 ($216 Million USD). However, this value could be criticised as a potential loss as Europe is the largest importing region of bamboo and Rattan products, accounting for 43% of the global import market ($679 million USD).

In 2012, industrialised bamboo products generated $538.5 million US Dollars or 29% the world's exports of bamboo and rattan. Products included bamboo flooring (68%), **bamboo plywood (21%)** and other smaller products, for instance bamboo pulp and charcoal (11%). Trade value of industrialised bamboo has fluctuated over the 20 years of this study having reached its highest record in 2007 and 2008. In the interest of this study it is noted that the trade value of bamboo plywood has seen a decline in the past years.

2.2.2.1 Trade of Bamboo and Rattan in Europe

The export and import value of bamboo and rattan products by the EU in 2012 reached $213 Million USD and $607 Million USD respectively.

This accounted for 11% of the world's total export market and 38% of the world's import market in bamboo and rattan trade.

The two biggest products exported from the EU to the world are; furniture and industrial bamboo based products, which contribute 33% and 30% respectively. Similarly, for imported products, furniture and industrialised bamboo products are the two major contributors which account for 25% and 24% of the total import value of bamboo and rattan for the EU.

The majority of bamboo and rattan imported to the EU was exported from China, amounting to 61% of the total import with the second largest being Indonesia.

With a market share currently undergoing growth, bamboo has the potential to be utilised more efficiently as a primary building material. Furthermore, research in the area of implementing engineered bamboo as a structural material is constantly increasing and showing that there could potentially be a case made for this material further increasing its market share. These studies on mechanical testing and structural evaluation will be evaluated further in the next chapter.

3.0 Engineered Bamboo Mechanical Properties: A Review

Bamboo as a material has been used in small local developments predominantly in Asia and South America for millennia. It is undeniable that bamboo has the capability to be considered as a structural material in its raw natural form. Many studies have been conducted on the application of bamboo in its natural form for construction purposes. A study by Albermania et al. (2007) on a lightweight bamboo double layer grid system indicate that, in practice using a special PVC jointing system devised by the team, these double layer grid systems could be applied for the construction of designs of small to medium span buildings. (Albermania, Goha, & Chanb, 2007) Furthermore, a study conducted by Yu et al. (2003) on the column buckling of structural bamboo demonstrates that *"The proposed design method applied by the researchers is shown to be structurally adequate in accordance with modern structural design philosophy, and it may be used effectively, to correctly and appropriately design structural bamboo (Phyllostachys Pubescens & Bambusa Pervariabilis) in bamboo scaffolds and other bamboo structures."* This study along with the availability of design data on the dimensions and the mechanical properties of structural bamboo, in its natural form, allowed structural engineers to take the advantages offered by bamboo to build *"light and strong bamboo structures to achieve enhanced economy and buildability"* (Yu, Chung, & Chan, 2003).

These studies show the potential use of bamboo in its raw natural form. While the studies outlined above are of minor interest to the research, a literature review of engineered bamboo solutions and laminated veneer bamboo in particular will be considered for this study. All studies reviewed here are conducted by persons outside this body of research and all knowledge presented is critically reviewed reference material and the results of any test presented are that of the referenced author of the study. Noting that some these studies are over 12 years old, more recent research by Meng et al 2015 and Dixon et al 2015 continue to advance the knowledge base of raw bamboo clums showing that bamboo has excellent energy absorption and show advances in data acquired from mechanical testing respectively.

3.1 ASTM International Standards

The studies that are reviewed in the coming chapter will make reference to a set of standards known as ASTM International, formally the American Society for Testing and Materials.

ASTM International *"is a globally recognized leader in the development and delivery of international voluntary consensus standards. Today, some 12,000 ASTM standards are used around the world to improve product quality, enhance safety, facilitate market access and trade, and build consumer confidence" (ASTM, 2015).* ASTM continually develops and improves their standards for testing materials. For this study reference will be made to standards developed by Committee D07 on wood. This Committee is involved in *"the promotion of knowledge, stimulation of research, and development of standards and related documents pertaining to forests, timber, wood, modified wood, veneer, wood-based structural panels, laminated wood and other multi-material structural composites in which cellulosic materials are a significant component".* Also worth noting is Subcommittee D07.02 on Lumber and Engineered Wood Products. (Shanahan, 2014)

In a study by C.S. Verma and V.M. Chariar (2012) in New Delhi, India on the development of layered laminate bamboo composite and their mechanical properties, dry bamboo culms of Dendrocalamus strictus were processed into thin laminas and cold pressed using epoxy resin to produce layered bamboo epoxy composite laminates. Mechanical properties of layered bamboo–epoxy composite laminates including tensile strength, compressive strength, flexural strength and screw holding capability were also evaluated. Modes of failures were identified at macroscopic level as suggested in each of the appropriate ASTM international test standards.

As part of this research three different layered laminate bamboo composites with different laminate configurations (different angles for each layer of laminate) were manufactured and tested. The three samples were orientated in 0^0, 45^0 and 90^0 angles.

In this case, the research team investigated the use of the *Dendrocalamus strictus* species to manufacture laminates. This was done by radial splitting a bamboo culm to create slats of bamboo. The slats were then sanded to remove the outer layer of the bamboo skin to more effectively apply the adhesive to the layers. Slats were then laminated together using *"liquid diglycidyl ether of bisphenol– A type (Araldite LY 556) with curing agent/hardener triethylene tetramine (TETA, HY 951)"* as an adhesive. An equation for determining the amount of adhesive required for each of the layers was also presented:

$$V_e = (n+1) \times L_p \times B_p \times T_e + n\,(B_p/B_s) \times L_p \times T_s \times T_e$$

Where V_e is the volume of adhesive,

n is the number of layers,

L_p is the length of ply,

B_p width of ply,

T_e thickness of adhesive coated,

B_s width of laminae

T_s thickness of laminae

This is an important equation for the environmental aspects of the research. The selection of adhesive, and the quantity used could have a significant effect on the structural capability as well as the environmental footprint of the product. These issues will be addressed further within the life cycle assessment section of the Literature review.

For flexural performance testing, five specimens of length 250mm **l** x 16mm **w** x 10mm **d** with 2mm laminae were assembled with tabs to ensure that failure occurred away from the grips when testing commenced. Flexural specimens were assembled according to ASTM D7264.

For compressive performance testing, five specimens of length mm 120 **l** x 16mm **w** x 5mm **d** with 1mm laminae were assembled. Compression specimens were assembled according to ASTM D3410.

For tensile performance testing, five specimens of length 250mm **l** x 16mm **w** x 10mm **d** with 2mm laminae were assembled with tabs to ensure that failure occurred away from the grips when testing commenced. Flexural specimens were assembled according to ASTM D3039.

The mechanical properties of the laminae were tested under tensile, compressive and flexural strength.

The results of the tests on these samples are presented in table 1 below.

Lamina configuration		Flexural		Compression		Tension	
		Max. stress	Max. modulu	Max. stress	Max. modulus	Max. stress	Max. modulus
		(N/mm^2)	(GPa)	(N/mm^2	(GPa)	(N/mm^2)	(GPa)
Sample A 0/0/0/0 /0	Max.	127	15.6	82.5	17.1	240	17.2
	Min.	125.3	12.3	78	12	191	14.3
	Mean	128.4	13.28	80	15	205	16
	S.D.	3.04	1.68	1.84	2.17	19.85	1.28
Sample A 0/45/0/45 /0	Max.	74.17	12.4	71.9	15.2	232	17
	Min.	58.99	8.3	48.6	12.6	175	13
	Mean	68.28	10.51	55	13.2	188	14.5
	S.D.	5.51	1.66	9.6	1.7	24.66	2.46
Sample C 0/90/0/90 /0	Max.	115.6	15.7	78.9	16.4	188	16
	Min.	89.6	11.6	49.5	12.3	160	12
	Mean	105.74	13.46	66	14	169	14.3
	S.D.	11.25	1.89	11.9	2.05	11.26	1.52

Table 1: Mechanical properties (Average) of LLBC's with different Lamina angles (C.S. Verma & Chariar, 2012)

It is concluded that if compared the laminated layer bamboo composites (LLBC) are on par with teak wood where fabrication costs less for the bamboo specimens. See table 2 below.

Comparison of mechanical properties and cost of LLBC's with teak wood		
Properties	Layered laminate bamboo composite at 10-12% moisture content	Teak wood at 10-12% moisture content
Tensile strength (MPa)	169-205 MPa	95-155 MPa
Compressive strength (MPa)	55-88 MPa	48-91 MPa
Flexural Strength (MPa)	68.27-128.4 MPa	86-170 MPa

Screw holding capability (N) on face/edge	1520-2636 N/1323-2603 N	1855N/1420 N
Density (kg/m$^{3)}$	715-890 kg/m^3	550-640 kg/m^3
Cost of Product	$27.22-35.28 per cubic foot	$58.80-94.08 per cubic foot

Table 2: Comparison of mechanical properties and cost of LLBC's with teak wood (C.S. Verma & Chariar, 2012)

In this instance, the comparison made with teak wood is justified in their study as it is the predominant, most widely available species of timber in the area. If we compare these laminates with more commonly used species in Europe, for instance spruce and pine, predominantly utilised in OSB and birch in plywood, all values for the bamboo laminates exceed and surpass the values of OSB and plywood. See table 3 below and table 4 on the page over for the mechanical properties of OSB and plywood respectively.

OSB Board

Thickness of OSB Board	**Flexural Strength**		**Compression Strength**		**Tensile Strength**	
	Bending Parallel to span	Bending Perpendicular to span	Compression Parallel to span	Compression Perpendicular to span	Tension Parallel to span	Tension Parallel to span
	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
	$f_{m,0,k}$	$f_{m,90,k}$	$f_{c,90,k}$	$f_{c,90,k}$	$f_{t,0,k}$	$f_{t,90,k}$
>6 - 10	18	9	15.9	1	9.9	7.2
>10 – 18	16.4	8.2	15.4	1	9.4	7
>18 - 25	14.8	7.4	12.7	1	9	6.8

Table 3: Mechanical Properties of OSB (Smart Ply) (Spruce)

Plywood

Thickness and origin of plywood		Flexural Strength		Compression Strength		Tensile Strength	
		Bending Parallel to span	Bending Perpendicular to span	Compression Parallel to span	Compression Perpendicular to span	Tension Parallel to span	Tension Parallel to span
		N/mm2	N/mm2	N/mm2	N/mm2	N/mm2	N/mm2
		$f_{m,0,k}$	$f_{m,90,k}$	$f_{c,90,k}$	$f_{c,90,k}$	$f_{t,0,k}$	$f_{t,90,k}$
12.5	American Plywood (Birch)	23.5	12.2	13.9	8.1	13.6	7.2
21	American Plywood (Birch)	14.8	10.1	10.6	7.7	10.5	6.9
12	Swedish Plywood (Birch)	23	11.4	15	12	15	12
24	Swedish Plywood (Birch)	21.6	12.4	15.4	11.4	15.4	11.4

Table 4: Plywood Mechanical Properties

A full comparison of laminated board products under study; OSB, Plywood and Laminated Veneer Bamboo (LVB) can be found in the next section.

It is stated by Verma et al (2012) that the laminated layer bamboo composites (LLBC) are more usable in terms of building and construction as it is adaptable in form. This however, can also be said for timber engineered products as thin laminates can be shaped and moulded into curved or obscure forms. The high flexibility in bamboo species such as *Phyllostachys Pubescens* lend itself better to this process and thus could be seen as a better more adaptable option for these types of applications. It is noted for the experiment that the tensile and compressive properties of LLBCs decrease with an increase in lamina angle as is presented in the 0/45/0/45/0 and the 0/90/0/90/0 lamina configurations. A combination of different factors could be used to decide the application of bamboo laminates due to the effect on the mechanical properties in relation to the lamina configuration (C.S. Verma & Chariar, 2012).

A further study by C.S. Verma et al (2014) on a comparative study of mechanical properties of bamboo laminae and their laminates with woods and wood based composites, also presents, through extensive research, that when compared with the structural properties established for wood and wood composites, for instance, OSB and plywood, the test results showed that LLBC's are a viable alternative to these wood based composites (C.S. Verma, Kr Sharmab, Naresh Chariarb, V.M. Maheshwaric, & S. Hadaa, 2014).[5]

In another joint study, conducted by Li, Zhang and Huang (2013) in the College of Civil Engineering, Nanjing Forestry University, Nanjing, China and Deeks (2013) in the Faculty of Science, Durham University, Durham, England the team assessed the compressive performance of laminated bamboo. This research, unlike the previous study, tested larger laminated bamboo sections under compression. The tests were conducted to establish if the sections could be used practically as primary structural columns in designs. In addition to this, it was carried out to determine if the strength of the section increased, decreased or remained stable with an increase in the sizing of the test section.

In order to investigate the compressive properties of structural laminated bamboo, 24 axial compression tests were performed. The bamboo for the specimens was sourced from three different growth heights of the bamboo culm (upper, middle and lower) with eight specimens

[5] This comparison can be seen in section 3.2 where a comparison of the mechanical data for OSB, American plywood, Swedish plywood and laminated veneer bamboo panels is conducted.

manufactured from each section of growth height. The section of each specimen was 100 mm x 100 mm and 300mm in height.

Specimens in this instance were tested using a micro-computer-controlled electro-hydraulic servo universal testing machine.[6]

The load was initially applied through load control. The load was increased linearly to 200 KN, at a rate of 0.7 KN per second. It was then reduced to 50 KN at the same rate. The load was then cycled linearly between 50 KN and 200 KN a total of six times in order to evaluate the elastic modulus accurately. The load was then increased linearly to 500 KN at the same loading rate, after which the testing process was changed to displacement control. This process was applied to all 24 laminates of bamboo.

Following on from initial loading the test continued at a displacement rate of 0.01 mm/s until the specimen had sustained significant damage, at which time testing was halted.

As per the testing by Verma et al. on the study of the development of layered laminate bamboo composite test were conducted to the failure of the material specimens or destructive testing.

A full breakdown of the process undertaken and the testing of samples by Li et al (2013) can be seen in the appendix.

The results of the compressive testing in relation to the specific growth portions of bamboo i.e. lower, middle and upper can be seen in table 5 below.

Growth portion	Average compressive strength	Standard Deviation	Average Elastic Modulus	Standard Deviation
	N/mm^2	N/mm^2	N/mm^2	N/mm^2
Lower	54.2	2.9	8641	196

[6] *This Servo Universal Testing Machine is manufactured according to international standards; ISO 7500-1, ASTM E4, EN10002-2, BS 1610, DIN 51221, ISO6892 and provides single test frame with dual zone to conduct Tensile, Compression and Flexural Test. Fully computerized models provides ease of use and customizable test result formats." servo-utm. (2014). Computerised Hydraulic Universal Testing Machine (Model : EKE-1509). Retrieved 16-05-2014, 2014, from http://www.servo-utm.com/servo_utm_1509.htm*

Middle	61.2	4.8	10,210	335
Upper	62.7	7.0	9322	362

Table 5: Mechanical properties of bamboo laminae according to Li et al (2013)

Effect of Growth portion of source bamboo

Figure 8 below shows the variation in ultimate stress amongst the test specimens plotted against the growth height group. Also plotted on the graph is the mean ultimate stress for each group and the characteristic strength of each group, calculated on the basis that 95% of samples will exceed the characteristic strength (mean ultimate stress – 1.645 x standard deviation). This figure shows clearly that although the mean strength increases slightly with the source growth height portion from 54.2MPs (lower) to 61.2MPa (middle) to 62.7MPa (Upper), the variation in the test results also increases. As a result, the characteristic strength decreases slightly with growth height, although this reduction in characteristic strength is small compared with the variation in the test results.

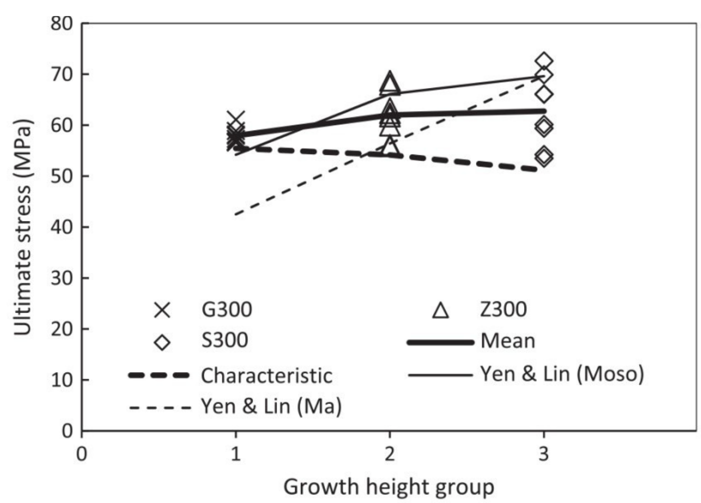


Figure 8: Effect of growth height on ultimate stress (Li et al 2013)

Figure 9 (over) plots the variation of elastic modulus with growth height. Unlike the strength results, the relationship is not monotonic (varying in such a way that it either never decreases or never increases), with the highest stiffness being measured for the specimens sourced from the middle growth height. The standard deviation of the results is again higher for the specimens from the middle and upper growth heights, but the variability of the results is smaller than the variability in compressive strength.

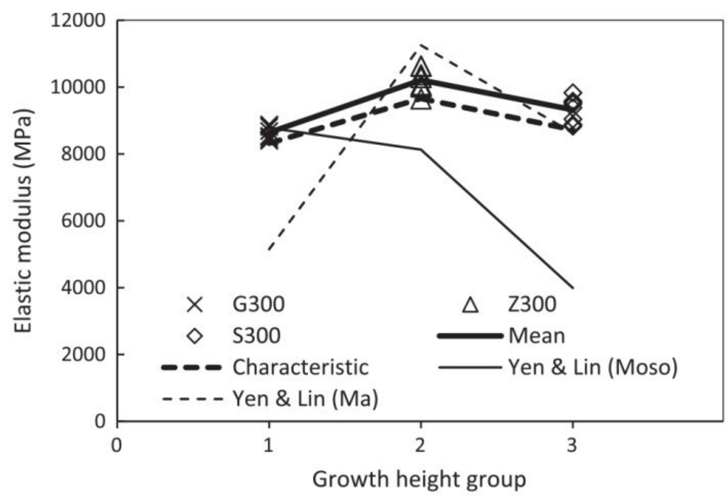


Figure 9: Effect of growth height on elastic modulus (Li et al 2013)

Based on the analysis of the 24 specimens and resulting test data, the following conclusions were drawn from the research;

A. "The mean compressive strength of the samples from higher growth heights was higher, although not to the same extent as has been observed in tests on smaller samples." This suggests that by laminating bamboo into larger laminated engineered sections it reduces the impact of the growth height of the original bamboo i.e. laminate sections can be sourced from any portion of the original bamboo without much effect on the strength.
B. "The variation of ultimate compressive strength increases with growth height."
C. "The elastic modulus is largest for the bamboo laminate sourced from the middle growth section. However, the growth height has very little variation in the elastic modulus "

D. "From a design point of view, the variation in compressive strength resulting from source bamboo growth height can be neglected. A tri-linear model based on a characteristic elastic modulus of 8200 MPa up to a stress of 40 MPa, then a modulus of 800 MPa up to a stress of 52 MPa, followed by perfectly plastic deformation to an ultimate strain of 50,000 μ was found to provide an appropriate structural design model for the average behaviour of the structural laminated bamboo tested."

Ultimately this stress–strain relationship shows that under compression laminated bamboo fails in a ductile manner[7] and has quite consistent strength and stiffness. Based on these compressive properties by Li et al (2012), it demonstrates that laminated bamboo is a suitable construction material for engineering structures.

Based on the outcomes of the two studies by Verma et al (2013) and Li et al (2012) it is identified that bamboo has the capability of being used as a suitable construction material for engineering structures. These test also prove that bamboo engineered products are on similar or exceeded the mechanical strength of timber making them an alternative and more sustainable solution. The next section will show a comparison of the widely used board products and their mechanical properties to evaluate the use of Laminated Veneer Bamboo (LVB) as an alternative construction material to wood composites.

An ongoing study at the Department of Architecture, University of Cambridge, Cambridge, UK (Sharma, Gatóo, Bock, & Ramage, 2015) have completed a piece of research and is currently testing and researching the potential of engineered bamboo for structural applications. In this initial study, by Sharma et al (2015), testing was carried out on two different engineered bamboo specimens; bamboo scrimber[8] and laminated bamboo. Testing in this instance is on structural elements (beams and columns). While both maintain the inherent strength of bamboo

[7] The capacity or ability of a material to deform permanently (e.g., stretch, bend, or spread) in response to stress. Britannica, E. (2016). ductility | physics. *Physics*.

[8] Bamboo composite type. Manufactured by saturation of crushed fibres in resin and compressing into dense block/beam/column.

by maintaining longitudinal fibre orientation, the products differ slightly in other aspects of their manufacture.

- **Bamboo Scrimber**
  - Utilises 80% of raw material inputs
  - Manufactured by saturation of crushed fibres in resin and compressing into dense block/beam/column
- **Laminated Bamboo**
  - Utilises only 30% of raw material input
  - Manufactured by splitting culm into strips, plaining strips until a rectangular end profile is achieved, processed (bleached or caramelised), laminated and pressed to form a board product.

Sharma et al set out to investigate the mechanical properties of both products and establish if there is a potential for use in a structural application. This was achieved by conducting a series of mechanical tests on the two products to establish the flexural, compressive, tensile, and shear strength of the products. Testing was conducted using standards set out by ASTM as well as British and European standards for timber. The following is a table of results extracted from the report by Sharma et al.

Testing for each category was conducted on ten specimens and an average value (x) was taken for the table of results on the page over (table 6) where:

COV=Coefficient of Variation
x - Average

a- Current Study
b- Study by Ghavami and Marinho: Determinição das propriedades mecanicas dos bambus das especies: moso, matake, Guadua angustifolia, Guadua tagoara e Dendrocalamus giganteus, para utilização na engenharia.
c- Study by de Vos: Bamboo for exterior joinery: a research in material properties and market perspectives.
d- Study by Lavers: The strength properties of timber, 3rd edition. Building Research Establishment
e- Study by Kretschmann: Mechanical Properties of Wood. In Wood Handbook, General Technical Report
f- Study by Kretschmann et al: Effect of various proportions of juvenile wood on laminated veneer lumber.
g- Study by Clouston et al: Incorporating size effects in the Tasi-Wu strength theory for Douglas-fir laminated veneer. Wood Sci Technol 1998;

Properties for structural bamboo and comparable natural bamboo and timber products.

		Density	Compression		Tension		Shear	Flexural		Eb/q
		q kg/m3	f c,0,k MPa	f c,90,k MPa	f t,0,k MPa	f t,90,k MPa	sk MPa	f_b MPa	E_b GPa	106 (m^2 s^{-2})
Laminated bamboo [a]	x	686	77	22	90	2	16	77–83	11–13	16–19
	COV	0.05	0.05	0.07	0.26	0.13	0.05	0.06–0.08	0.05–0.06	
Bamboo Scrimber [a]	x	1163	86	37	120	3	15	119	13	11
	COV	0.02	0.02	0.05	0.14	0.13	0.11	0.08	0.04	
Raw bamboo Phyllostachys Pubescens [b,c]	x	666	53	–	153	–	16	135	9	14
Sitka Spruce [d,e]	x	383	36	–	59	–	9	67	8	21
Douglas-fir LVL [f,g]	x	520	57	–	49	–	11	68	13	25

Table 6: Properties for structural bamboo and comparable natural bamboo and timber products (Sharma et al. (2015))

"Results of the test show that the bamboo scrimber has slightly better mechanical properties with the exception of shear parallel to grain." (Sharma, et al., 2015) than all other materials tested or referenced.

This is due to the density of the material fibres within the finished product as well as their bond with the phenol formaldehyde resin.

It can also be seen from this table that engineered bamboo products, manufactured with Phyllostachys Pubescens, have comparable properties with other structural materials such as timber and raw bamboo.

As this study is still in the early stages a summary is presented at the conclusion of the report stating further areas of research. These include:

- *"Further work on the processing of materials to achieve desired caramel colour. This is a process achieved through heat treatment resulting in a high environmental impact."(Sharma, et al., 2015)*

- *"Further research into the influence of layer orientation"(Sharma, et al., 2015)*
- *"Further research on the effect of moisture and density on the mechanical properties is required to develop design characterisation factors for engineered bamboo."(Sharma, et al., 2015)*
- *"Additional testing on full scale specimens rather than on small scale specimens."(Sharma, et al., 2015)*

While it shows promise for engineered bamboo as a structural material in beams and columns it still appears that the lack of specification, design, building methods and standards hinder its implementation. In order to address these issues a standardised panelised building system will be designed as part of this research using a 2440mmx1220mm laminated veneer bamboo sheet. See section 5.0 Panelised Building System Design for further information on this,

These selected studies show that laminated bamboo/bamboo composites have the potential to be used as an alternative to timber products in construction. The extent of their use however has yet to be fully determined due to a lack of full scale testing and implementation into large architectural schemes.

With this in mind the next chapter will explore and compare the mechanical properties of three of the most widely used sheet products (OSB, American Ply, Swedish Ply) with the most advanced laminated veneer bamboo sheet alternative.

3.2 Comparison of Mechanical Data for OSB, American Plywood, Swedish Plywood and Laminated Veneer Bamboo panels

The following is a comparison of board/sheet products under different mechanical properties; flexural and compressive strength, modulus of elasticity, shear strength and tensile strength. The mechanical properties for each of the materials in question were sourced from the market leading companies that produce these products. The values and figures presented were extracted from data sheets provided by SmartPly OSB/Plywood and by Lamboo© Inc. None of the mechanical properties presented were the result of any testing conducted by the author of this research or any persons associated with this research. The comparison of the materials and all comments associated to the comparison are the work of the author.

In order to ensure a comparison can be made between these products the means by which they are tested must first be evaluated. All materials were tested to ASTM international standards and sample sizes were manufactured according to ASTM 3501 for compressive strength testing, ASTM 3500 for tensile testing, ASTM D3043 for flexural testing, ASTM D3048 for shear testing and ASTM D 1037 for determining elastic modulus. ASTM international is an internationally recognised standards organisation. The ASTM testing of materials is similar to testing set out by The International standards organisation (ISO) and Eurocodes who follow the guidelines set out by ISO. The data was critically reviewed and test methods were evaluated against those of European Standards. This process was carried out as the majority of the research for bamboo specimens was conducted using an American standard for testing materials (ASTM) now ASTM international. (America Standards for Testing Materials ASTM, 2012) (Lamboo, 2014) This review of standards showed identical testing procedures when compared to European standards. Relevant data was compiled and presented to show the capability of LVB against similar building products for instance Plywood and Orient Strand Board (OSB).

Test Specimen sizes for testing of board products are presented at the beginning of each sub-chapter. A thickness of 12mm has been given to the laminated veneer bamboo. All other materials are presented with their thickness.

3.2.1 Flexural Strength

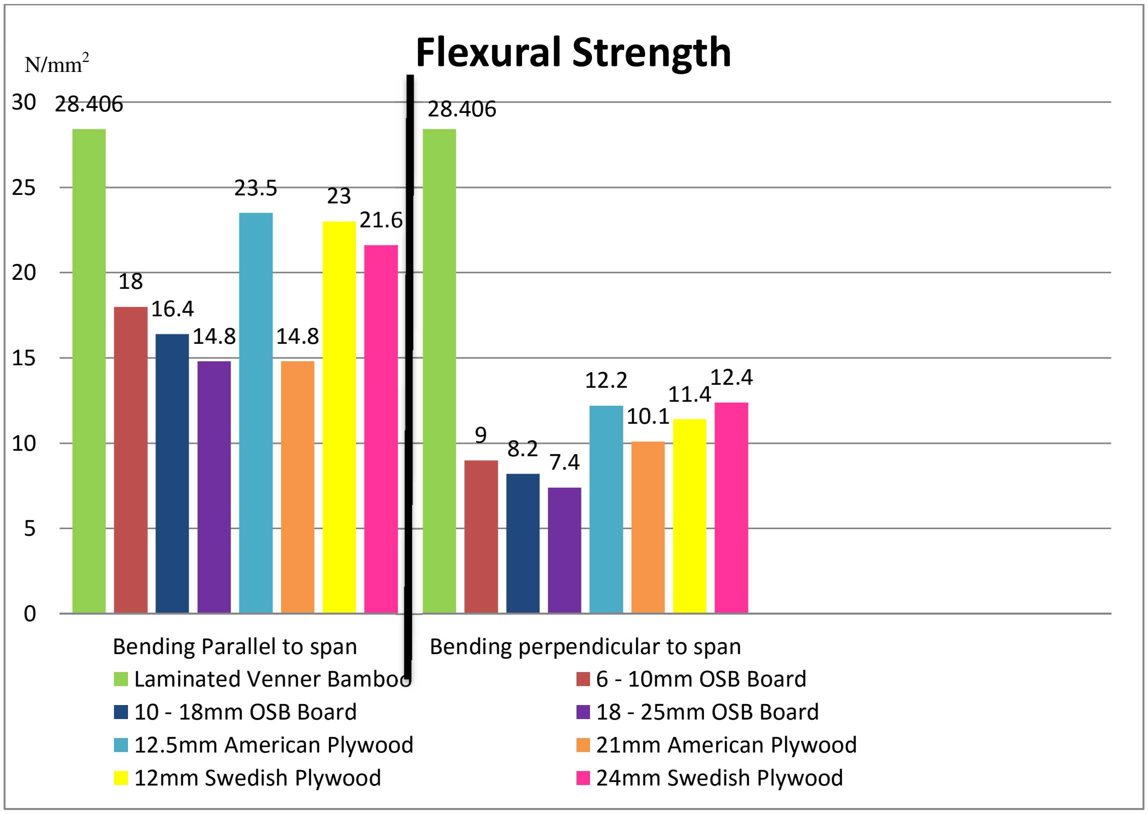


Figure 10: Comparison of Flexural strength for different sheet products

According to ASTM D3043 "The depth of the specimen shall be equal to the thickness of material, and the width shall be 1 in. (25 mm) for depths less than 1⁄4 in. (6 mm) and 2 in. (50 mm) for greater depths. When the principal direction of the face plies, laminations, strands, or wafers is parallel to the span, the length of the specimen shall be not less than 48 times the depth plus 2 in.; when the principal direction of the face plies, laminations, strands, or wafers is perpendicular to the span, the specimen length shall be not less than 24 times the depth plus 2 in." (American Standards for Testing Materials ASTM, 2011a)

Figure 10 above shows the flexural strength of three different board products, OSB, Plywood, and Bamboo laminate board. The bamboo board exceeds all OSB and Plywood products by 74% in the lower region and 17% in the higher region. Based on the data provided, in all cases Bamboo laminate boards exceeded in flexural strength when compared to OSB and Plywood.

3.2.2 Compressive Strength

According to ASTM standard D 3501:

"the test specimen shall be rectangular in cross section. The thickness, width, and length of each specimen shall be measured to an accuracy of not less than ± 0.3 % or 0.02 mm, whichever is larger.

For Material Over ¼ in. (6 mm) in Thickness, the specimens shall have a thickness equal to that of the material and the width shall be a minimum of 1 in. (25 mm) but not less than the thickness. The length shall be not greater than seven times the least cross-sectional dimension.

For Material ¼ in. (6 mm) or Less in Thickness, the specimen shall have the following dimensions: thickness equal to that of the material; the width nominally 1 in. (25 mm); and length 4 in. (100 mm). Such specimens shall be supported laterally throughout the test.

When tests to evaluate maximum compressive strength only are required, an alternative type of specimen 4 in. (100 mm) in width and a length equal to six times the thickness may be used." (American Standards for Testing Materials ASTM, 2011c)

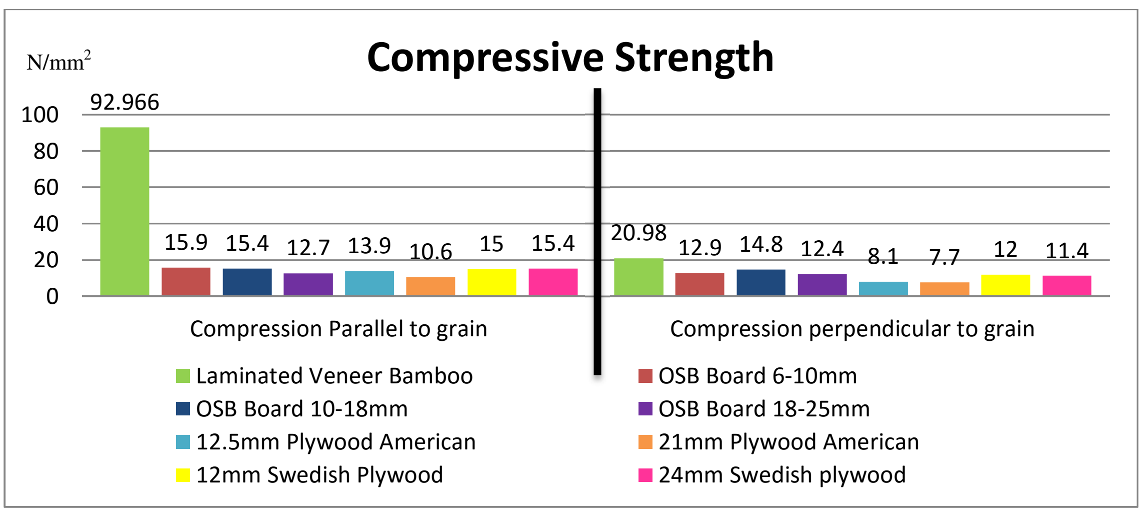


Figure 11: Comparison of Compressive strength for 3 sheet products

Figure 11 above shows the compressive strength of three different board products, OSB, Plywood, and Bamboo laminate board. The bamboo board exceeds all OSB and Plywood products by 88% in the lower region for compression parallel to grain and 82% in the higher region for compression parallel to grain. The bamboo board exceeds all OSB and Plywood products by 37% in the lower region for compression perpendicular to grain and 29% in the higher region for compression perpendicular to grain. Based on the data provided, in all cases Bamboo laminate boards exceeded in compressive strength when compared to OSB and Plywood.

3.2.3 Shear Strength

The test specimen shall be square, with the thickness equal to the thickness of the material, and the length and width not less than 25 or more than 40 times the thickness. The thickness, length, and width of each specimen shall be measured to an accuracy of not less than ± 0.3 %. (American Standards for Testing Materials ASTM, 2011b)

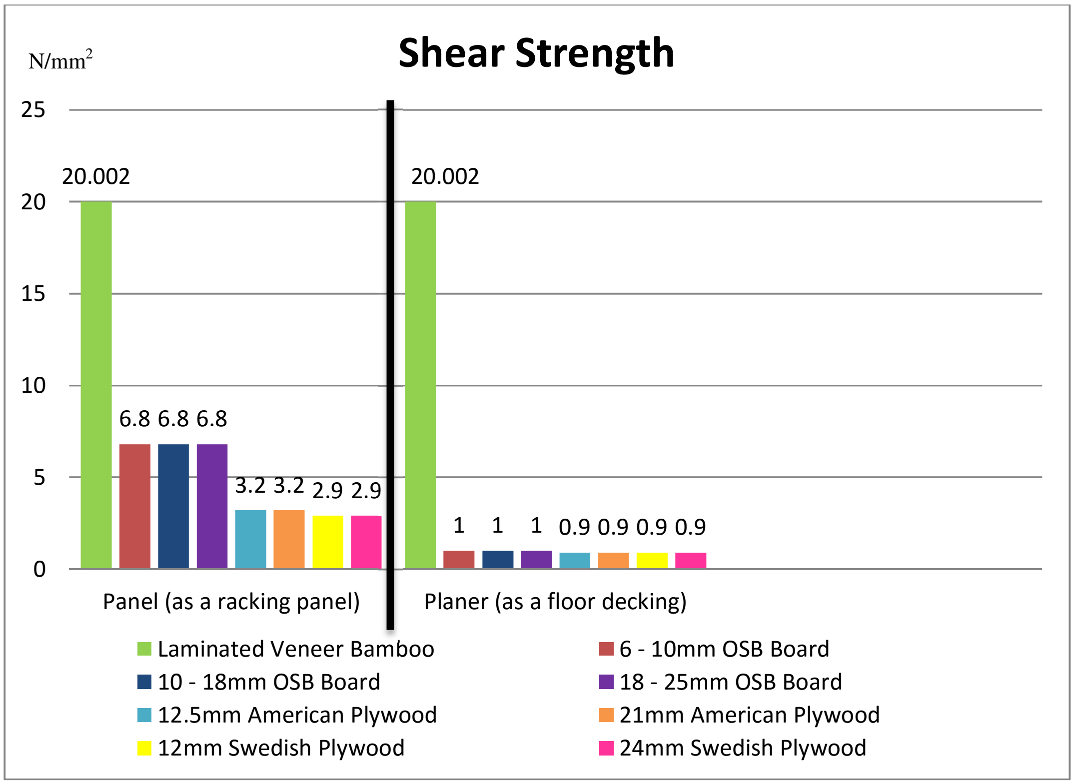


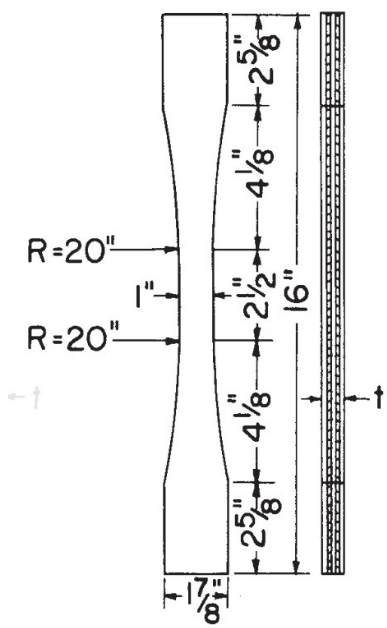
Figure 12: Comparison of Shear Strength for different sheet products

Figure 12 previous shows the shear strength of three different board products, OSB, Plywood, and Bamboo laminate board. The bamboo board exceeds all OSB and Plywood products by 95% in the lower region and 66% in the higher region. Based on the data provided, in all cases Bamboo laminate boards exceeded in shear strength when compared to OSB and Plywood.

3.2.4 Tensile Strength

According to ASTM standard D 3500:

Test specimens shall be manufactured to the dimensions set out in the image below (figure 13) "this test sample size shall be used regardless of the thickness of the material. The specimens shall have a thickness equal to that of the material. The thickness and the width of each specimen at the critical section shall be measured to an accuracy of not less than 60.3 % or 0.001 in. (0.02 mm) whichever is larger." (American Standards for Testing Materials ASTM, 2009)



Imperial Units (inches)	Metric Equivalents (mm)
1/4	6
1/2	13
1	25
1 7/8	48
2 1/2	64
2 5/8	67
2 7/8	73
3 7/8	98
4 1/8	105
4 1/4	108
16	406
20	503
25	635
30	762

Table 7: Test sample for Tension test

"test specimen shall be square, with the thickness equal to the thickness of the material, and the length and width not less than 25 or more than 40 times the thickness. The thickness, length, and width of each specimen shall be measured to an accuracy of not less than ± 0.3 %."

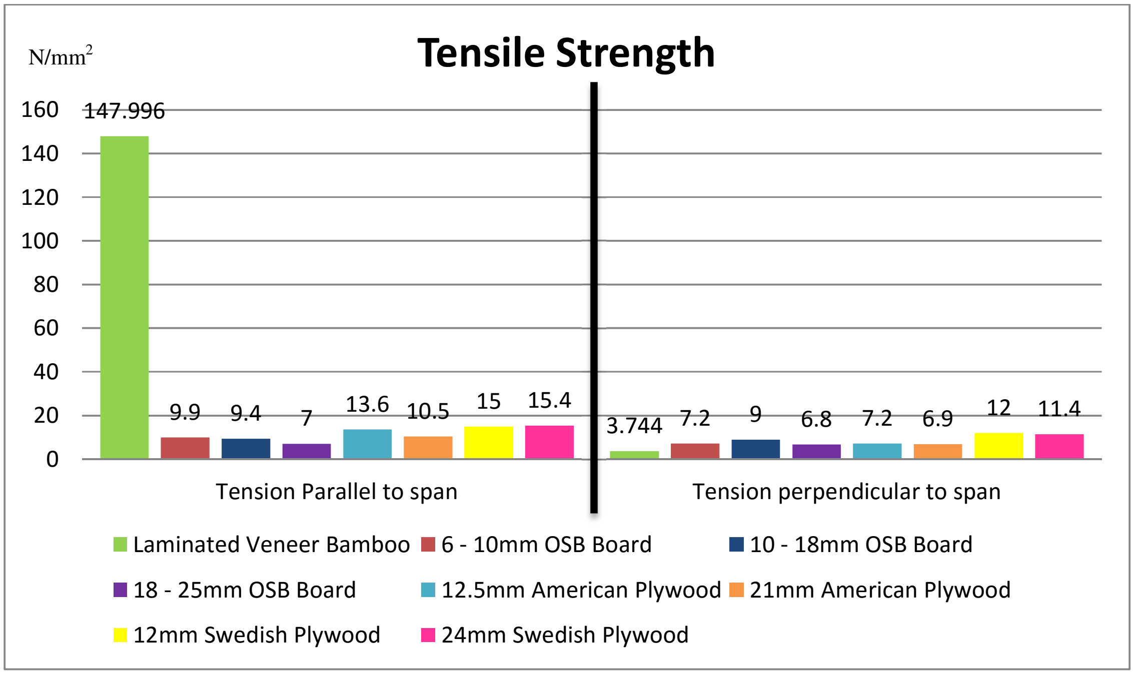


Figure 13: Comparison of Tensile strength for different sheet products

Figure 14 above shows the tensile strength of three different board products; OSB, Plywood, and Bamboo laminate board. Based on the data provided the bamboo board exceeds all OSB and Plywood products by 95% in the lower region for tension parallel to span and 90% in the higher region for tension parallel to grain. The bamboo board performs worse compared to all OSB and Plywood products by 45% in the lower region for tension perpendicular to grain and by 69% in the higher region for tension perpendicular to grain. Interestingly as see from the comparative results depicted in the previous table the only mechanical property which the bamboo laminate boards does not exceeded when compared to OSB and Plywood is this test on tension perpendicular to grain.

3.2.5 Modulus of Elasticity

Figure 15 below shows the elastic modulus of three different board products, OSB, Plywood, and Bamboo laminate board. The bamboo board exceeds all OSB and Plywood products by 92% in the lower region and 60% in the higher region. Based on the data provided, in all cases Bamboo laminate boards exceeded in elastic modulus when compared to OSB and Plywood.

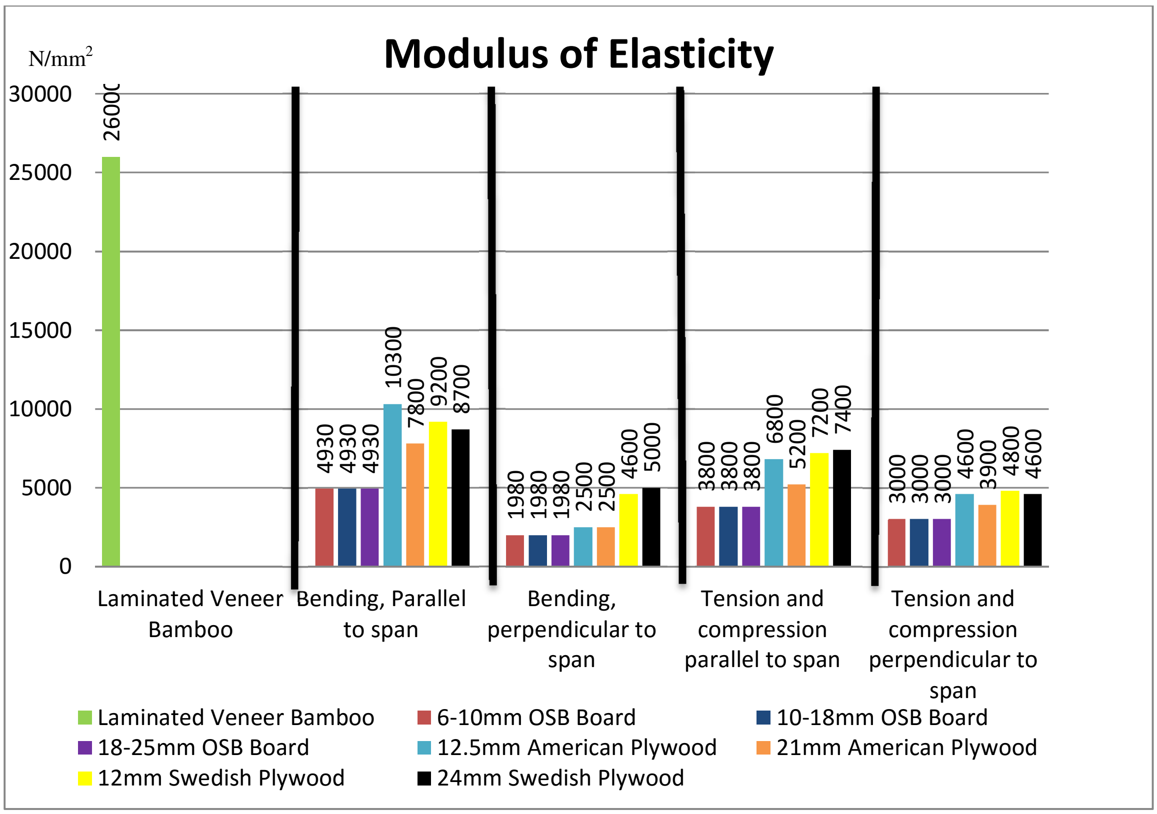


Figure 14: Comparison of Elastic modulus for different sheet products

From these simple comparisons we can see that the laminated veneer bamboo product excelled in all but one of the test areas.

A full break-down of the data in the graphs previous is depicted in table 8.

It is fundamental that if laminated bamboo is to be considered as a usable building material further research is needed on the mechanical properties of the sheet material including and taking into account a factor of safety. Furthermore, how the material is used i.e. as a sheet material, in a column or beam system or in a panelised system could change the structural characteristics of the material. This is particularly noticeable when using the material for high rise construction where the members used in the lower stories will be under considerably more load than that of the members used in the upper storeys of a buildings structure. The behaviour of the different ways LVB could be used needs further research and set of mechanical data need to be established for each system design.

Structural Characteristic		Laminated veneer Bamboo (LVB)	6-10mm OSB	10-18mm OSB	18-25mm OSB	12.5mm American Plywood	21mm American Plywood	12mm Swedish Plywood	25mm Swedish Plywood
Felexural Strength (Paraellel to span)	N/mm^2	28.406	18	16.4	14.78	23.5	14.8	23	21.6
Perpendicular to span	N/mm^2		9	8.2	7.4	12.2	10.1	11.4	12.4
Shear Strength(as racking)	N/mm^2	20.002	6.8	6.8	6.8	3.2	3.2	2.9	2.9
As floor decking	N/mm^2		1	1	1	0.9	0.9	0.9	0.9
Tensile Strength (Parallel to Grain)	N/mm^2	147.996	9.9	9.4	7	13.6	10.5	15	15.4
Perpendicular to grain	N/mm^2	3.744	7.2	9	6.8	7.2	6.9	12	11.4
Compressive Strength Parallel to grain	N/mm^2	92.966	15.9	15.4	12.7	15.9	10.6	15	15.4
Perpendicular to grain	N/mm^2	20.98	12.9	14.8	12.4	8.1	7.7	12	11.4
Modulus of Elasticity	N/mm^2	26000							
Bending parallel to span	N/mm^2		4930	4930	4930	10300	7800	9200	8700
Bending Perpendicular to span	N/mm^2		1980	1980	1980	2050	2050	4600	5000
Tension and compression parallel to span	N/mm^2		3800	3800	3800	6800	5200	7200	7400
Tension and compression Perpendicular to span	N/mm^2		3000	3000	3000	4600	3900	4800	4600

Table 8: Comparison of Mechanical Data Sheets for LVB, OSB and Plywood

3.3 Fire Performance

When approaching the design of a building using a wood based product, it is critical to ensure all available fire safety measures are put in place to provide the occupants with a safe place to live. Bamboo, similar to timber, has the potential to be viewed as a material unsafe for use due to the stigma that it will ignite and burn rapidly. This however, is not the case.

Studies have shown that wood based structure particularly heavy timbers[9] are at a particular advantage due to the materials ability to char on the outer layer, slowing the rate at which the timber is burnt. This allows the inner layers to retain their structural integrity and allows building occupants time to evacuate safely. (ReThink, 2015)

It can be suggested from studies by Josué Mena et al (2012) and Xiao et al (2012) that Bamboo reacts in a similar way to that of timber, i.e. predictable. Similar to timber, bamboo and laminated bamboo provide resistance to flame spread through a charring layer. As well as this extra measures can be put in place to reduce the risk of heat and flame spread to the critical elements of the buildings structure. Products such as gypsum plaster board and flame retardant materials can be utilised to provide a barrier to bamboo or timber.

In a study conducted by Josué Mena et al at the Department of Construction Engineering and Management, School of Engineering, Chile the fire reaction of bamboo (Guadua angustifolia kunth in this instance) was studied based on fire ignition and flame spread. Such parameters allow an understanding of the way that a material contributes to its own pyrolysis[10] and spread of fire. In addition, fire resistance was studied based on charring behaviour and flexural strength at high temperatures." (Mena, Vera, Correal, & Lopez, 2012)

According to the experimental research, in relation to fire spread, round Guadua bamboo resulted in a critical flux of 5.1kW/m^2 while glue laminated Guadua (GLG) resulted in a value

[9] Cross laminated timber (CLT) and laminated veneer lumber LVL
[10] Pyrolysis is chemical reaction. This reaction involves molecular breakdown of larger molecules into smaller molecules in presence of heat.

of 10.4kW/m^2. Comparing this to the critical flux of some timbers the values are similar or exceed some timbers. See appendix 2.ii for critical flux of some timber species.

The table (table 7) below shows the charring rate for the materials under study in this research.

Material	Charring Rate mm/min	
	Use as finishing Element	Use as a Structural Element
Round Guadua	0.24mm	0.20mm
Laminated Guadua	0.59mm	0.48mm
Plywood	0.65mm	0.48mm

Table 9: Charing rate of Guadua Bamboo, Laminated Guadua and Plywood (Mena et al 2012)

What is evident from the table is that round Guadua presented the lowest charring rate among the three materials under study by a significant margin, approximately 40% less than GLG and plywood. Compared to LVL, Laminated Guadua has approximately a 41% more efficient charring rate. (Frangi, 2012) The significant difference can be explained by the differences in microstructure. Interesting to note from this table is the similarities between Laminated Guadua and plywood. Both have a similar charring rate when used as structural elements which are consistent with the values indicated in the international design codes.

Advancing on this, a study by Xiao et al, at the Ministry of Education Key Laboratory of Building Safety and Energy Efficiency, Hunan University, China, (Xiao & Ma, 2012) conducted a full scale fire simulation on a room unit constructed from Glubam wall panels. i.e. 40mm x 84mm glue-laminated bamboo wall studs with 10mm plybamboo externally 10mm gypsum board internally and 84mm heat insulation material between studs. See image 16 below.

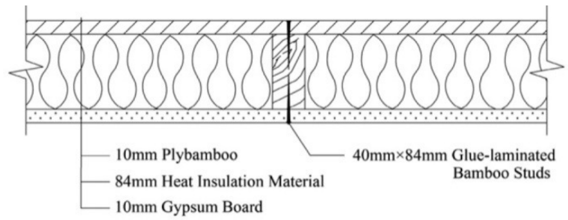


Figure 15: Wall construction for fire simulation (Xiao et al 2012)

Gypsum board used in this instance may have been a poor choice. If plybamboo was located on either side of the studs a more comprehensive study could have been undertaken on the bamboo performance. However, as the author suggested, typical internal linings would usually incorporate gypsum board.

The experimental results present a series of events occurring at different time frames throughout the fire simulation period, from ignition of the wooden crib, to the final extinguishment of the fire, as well as, a review of the structure 12 hours later. For a full breakdown of the integrity of the test room over an hour long period see appendix.

It is reported that after 1 hour of exposure to fire the structural integrity of the room unit was retained although weakened slightly. Critically, there was no complete burning through of the slab or walls. However, as mentioned before the gypsum board had a major effect on the fire resistance performance of the internal faces of the room unit. However, the results from Mena et al (2012) discussed previously present bamboo in a favourable way in relation to flame spread and fire resistance.

The average charring depth of bamboo studs was less than 25% of the sectional dimension due to the protection from gypsum boards installed on surface of walls.

A more thorough inspection 12 hours after the extinguishment of the fire revealed a smouldering zone near the upper portion of a section of wall. A small hole was formed in the wall and a small portion near the end of a beam was burnt for about a quarter of the beam depth due to the smouldering. These phenomena illustrate the good resistance of the Glubam elements once charring is formed.

What these studies demonstrate is that based on good design principles fire protection of laminated bamboo structures can be achieved. Implementing such measures as increasing structural members to provide a charring layer or by using a fire protective layer such as gypsum plaster board means that the integral strength can be safely protected from fire, thus allowing building occupants time to safely exit a structure should they need to.

Given that modern day fire resistance is calculated on minute or hourly protection rates, most commonly 30,60(1h) and 120(2h) minute, based on the charring results shown by Josué Mena et al (2012) to achieve a fire resistance of 60min a sacrificial or charring layer of 28.8mm (30mm) would be require surrounding the structural member protecting its integrity. This would subsequently be doubled to 57.6mm (60mm) for a 2 hour fire resistance.

3.4 Life Cycle Analysis: Literature Review and Benchmark Test

3.4.1 Introduction

Life cycle assessment (LCA) is an internationally recognised method for assessing the potential environmental impact of a certain material or process for its entire life cycle (Cradle to Grave/Cradle) or part of that life cycle (Cradle to Gate). A life cycle assessment is completed, by:

- Compiling an inventory of relevant energy and material inputs and environmental releases
- Evaluating the potential environmental impacts associated with identified inputs and releases
- Interpreting the results to help you make a more informed decision (O. US EPA, Sustainable Technology Division, 2012)

Life Cycle assessments are broken down into different profile types. These profile types are shown in table 8 on the following page. These profile types define the parameters and extents of a life cycle study or system boundary.

There are four phases in an LCA study:

- a) The goal and scope definition phase,
- b) The inventory analysis phase,
- c) The impact assessment phase, and
- d) The interpretation phase.

Profile Type	Life Cycle Stages Included	Study Units	Use for Comparison	Responsible Party
Cradle to gate	Production stage (raw material supply, transport and manufacturing of products and all upstream processes from cradle to gate	Information module: per tonne	Shall not be used for comparison	In-factory (gate to gate) data collected by manufacturer Per-factory data for raw materials provided by BRE Certification Ltd
Cradle to site	Production stage (raw material supply, transport, and manufacturing of products and all upstream processes from cradle to gate. Construction process stage (transport to the building site and wastage from building installation/construction only) including transport and disposal of waste.	Information module: per meter^2 installed element	Shall not be used for comparison	As above and Construction process data provided by BRE Certification Ltd
Cradle to grave	As above and Use stage: repair, replacement, maintenance and refurbishment including transport of any materials and disposal of waste over the 60 year period. Demolition: is expected to occur at any time at or after the end of the study period and it includes transport and disposal of waste.	Functional Unit: Per square meter installed element over a sixty year period in the building	Can be used for comparison if the functional unit is equivalent	As above and Life time data by BRE Certification Ltd

Table 10: Description of life cycle stages (ISO, 2013)

Cradle to Cradle

Cradle to cradle design is a biomimetic[11] approach to the design of products and systems. It models the human industry on nature's processes viewing materials as nutrients circulating in healthy, safe metabolisms (Braungart & McDonough, 2008).

In relation to the subject here a cradle to grave profile will be selected for the ability to compare different design/material options. The materials in question will be bamboo as it is manufactured into usable building products and timber as it is manufactured into usable building products. These building products will then be applied to an architectural design and building method and eventually be evaluated at the end of life phase. The stages of the life cycle that will be assessed are as follows:

[11] **Biomimetic:** The imitation of the models, systems, and elements of nature for the purpose of solving complex human problems.

- Raw material extraction
- Product manufacture (Laminated Veneer bamboo) and associated emissions
- Building Applications
- End of life and associated emissions

3.4.2 Benchmark Test

An initial comparative life cycle test was carried out on Cross laminated timber (CLT) and laminated veneer bamboo (LVB). This benchmark was conducted to establish if the application selected was capable of conducting the test under the criteria which was set up as well as to establish if the initial hypothesis had any potential to be explored further. This initial cradle to grave benchmark test using the Tally® Application within Autodesk Revit® presented interesting data.

Tally® is an application which conducts a cradle to grave life cycle assessment (LCA) using an Autodesk Revit® model which has been embellished with specified materials. The cradle to grave LCA is selected automatically based on the fact that that option is the only profile that can be used to conduct a comparison. Launched in November 2013 Tally® has been the recipient of a national award from the American Institute of Architects for Life cycle assessment in building design and is continually updating and developing its application and databases. Tally® was developed by American based architectural planning and research practice Kiernan Timberlake in association with Autodesk and PE international (now thinkstep), a well-established and recognised Life Cycle and environmental footprint consultant.

Autodesk Revit® is a 3D modelling application used in a process called Building Information Modelling (BIM). A user can create a detailed digital building model using the drawing tools provided and assign specific information and data such as materials and their properties as well as producing fully detailed drawings and schedules. This results in a building information model that can be used by a design team to execute a project.

For this benchmark test a Revit model was created with two options for the same design:

- Option A - Cross laminated timber (CLT) as the primary structural material
- Option B - Laminated veneer bamboo (LVB) as the primary structural material.

The building was a single story, 70m^2 studio/office space, with a CLT or LVB flat roof and wall construction depending on the selected design option (Figure 17). Also included was a standard concrete bearing ground floor, with concrete block rising-wall and strip foundations. The building was externally insulated to current Irish building regulations and finished with an acrylic render. In both design options the only material that differed was the primary structural material. In all other cases all elements and materials were treated identically.

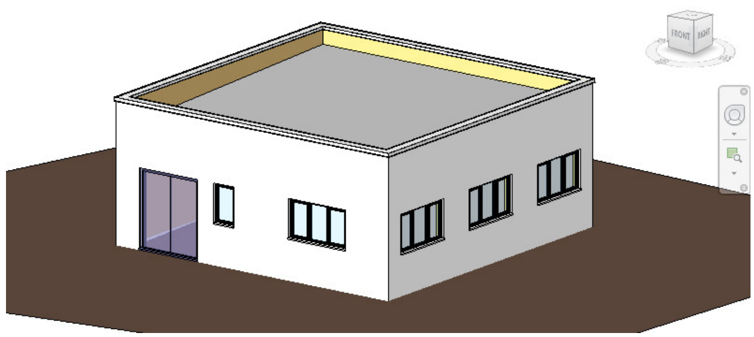


Figure 16: Benchmark test model

3.4.2.1 Tally© (Assigning materials):

As has been previously stated Tally® is an application which conducts a life cycle assessment using an Autodesk Revit® model which has been embellished with specified materials. Using the application the materials can be assigned a Tally material from the life cycle database. The application window will display two things:

- The project browser; which includes the specific design option and the related system (walls, floors & roofs) and component families (Structural framing, doors etc.) and the Revit® material associated with the family type.
- The Information; which displays the **Revit® take-offs, Revit® material**, **Tally® Entry** (Life Cycle material data), **Description** of Tally® entry and the **Materials**

associated to the tally® entry once an object has been selected. See figure 18 on the page over.

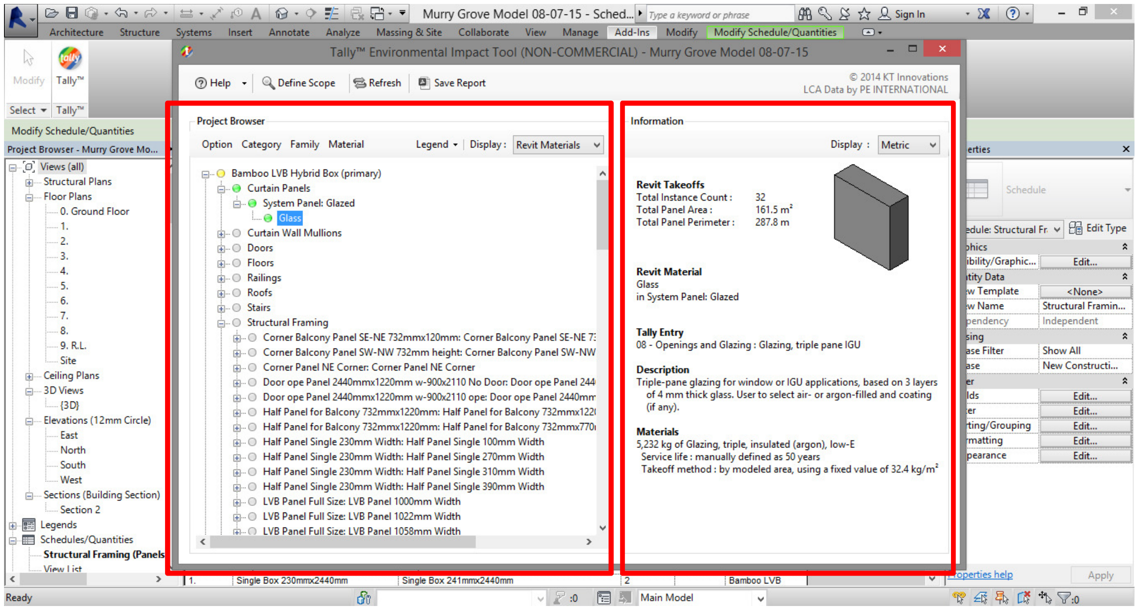


Figure 17: Tally®: Project Browser

By right clicking on the Revit® material as seen in figure 18 above a menu will be presented where you can select edit definition (See figure 19 below). From here Tally® materials can be assigned to the Revit® material that has been selected. These LCA materials will include all the relevant LCA metadata and will eventually be exported to complete the life cycle analysis.

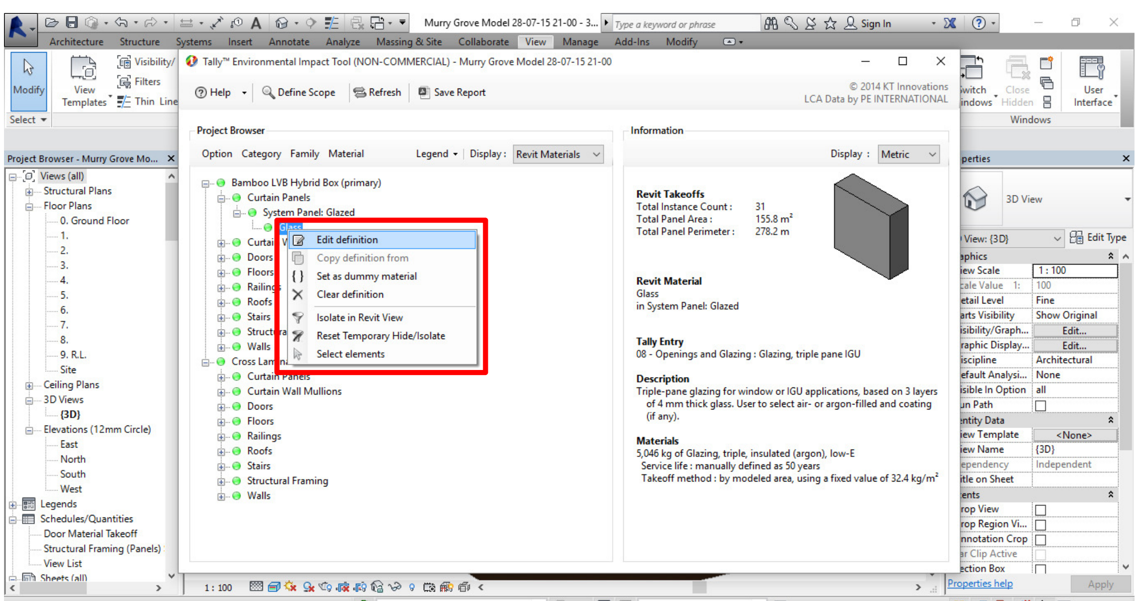


Figure 18: Tally®: Editing material definition

The Tally® database will display categories of materials and through these categories specific materials can be assigned to the Revit® take-offs. See figure 20 below.

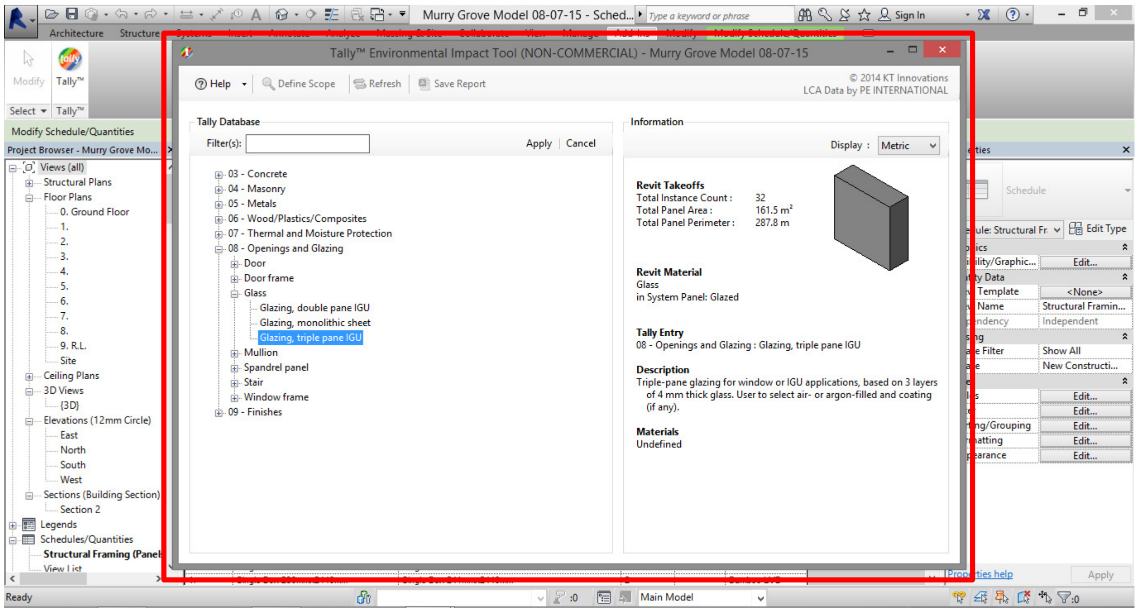


Figure 19: Tally®: Material database

Once the material has been selected from the Tally® database the user can define the specific material type (in the instance in figure 21 below the glazing type). The service life and take off method (modelled area or modelled volume) must also be specified in order to complete the material category selected.

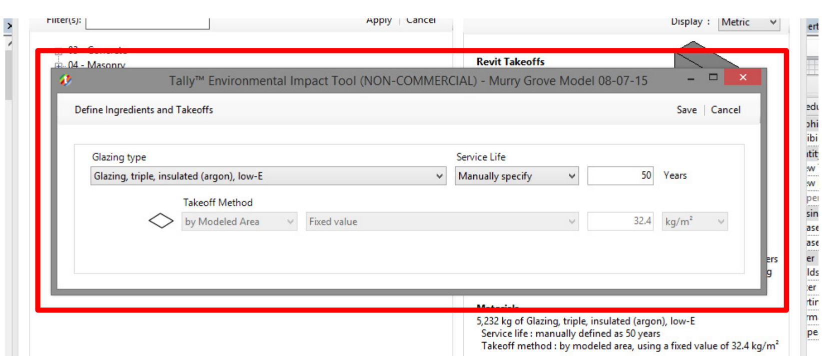


Figure 20: Tally®: Defining materials ingredients and Take-offs

When the material has been assigned the main project browser will display a green dot alongside the material. If the material has not been fully defined, or if an invalid definition has been assigned in relation to that family type or Revit® material, a red or yellow dot will be displayed alongside the family type. If this occurs the user must repeat the steps to define materials and check that the Tally® material assigned is specified fully and correct. (See figure 22 below.

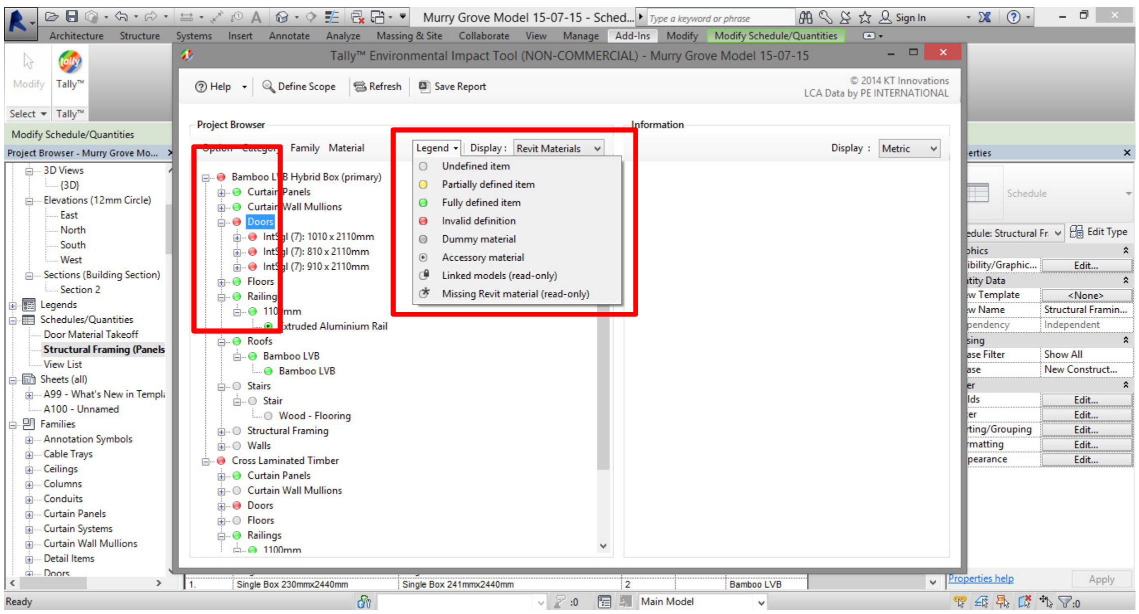


Figure 21: Tally®: Completed material definitions and invalid materials

3.4.2.3 Results

Laminated veneer bamboo (LVB) is not available for selection within the Tally® database so in order to conduct the benchmark LCA study bamboo plank flooring is substituted for LVB. An assumption is made here that the manufacturing process for LVB and Bamboo plank flooring is similar. In fact they differ slightly. (See manufacture chapter previously Section 2.1.1.1) Wall and roof thickness were kept the same in the test model. However, there is an assumption based on the structural data analysed previously that it could be reduced for the LVB solution. However, for the basis of this benchmark test similar sizes were used for both options.

The sizing of walls, internal and external, and roof structure are listed below:

1. External walls: 120mm thick in both cases
2. Internal walls: 100mm thick in both cases
3. Roof Structure: 140mm thick in both cases

For this research only global warming potential (GWP) (kg/CO_2e) is being measured. The results of the LCA are as follows:

- The overall weight (mass) of bamboo required was less than that of CLT by 2225Kg
    - CLT = 13,520.2 kg
    - Bamboo Plank (Flooring) = 11,295.2 kg

The isolated bamboo material had a lower global warming potential (GWP) at **14,007 kgCO_2e.**

CLT had a marginally higher value of **14,127 kgCO_2e.**

Interestingly the overall GWP was lower in the CLT construction design option than in the design option with Bamboo by 1734 kgCO_2e.

- CLT = **306,723 kgCO_2e**
- Bamboo = **308,457 kgCO_2e**

The values shown here for the two different design options also appeared extremely large compared to the reset of the LCA data. Given this a review of the Revit model and a review of the LCA data was undertaken to see where the differences were between the two design options.

3.4.2.4 Revision/Data analysis

On a revision of the model, fixes were made to the doors and windows to ensure they were approached in the same way for both design options. The placement of doors and windows are not essential to the overall scope of the study but may cause anomalies in the data output if they are not similar in both instances. The floor slab is similar in both studies. The wall build up in both design options is exactly the same, with obvious changes made to the primary structural material in each design option.

Technically speaking the model was identical in both instances other than the differing primary construction materials, CLT and LVB. By isolating the bamboo material and the CLT material in the revised model again it can be seen that bamboo performs marginally more favourably in GWP. See Table 9 below.

Material	$KgCO_2e$
Laminated veneer bamboo	13,962
Cross laminated timber	14,410

Table 11: Benchmark LCA: Isolated Laminated veneer bamboo and Cross laminated timber

Having already stated that the models are identical in nature it is interesting that the overall outcome[12] is that the design option containing bamboo comes out less favourably. After correspondence with the Tally® application developers it was noted that a urethane adhesive is specified for bamboo flooring resulting in a total of approximately 1,300 $kgCO_2e$ not accounted for in the CLT design option. This is an extra layer of data inputted as part of the bamboo plank flooring LCA database material in Tally®. Technically it is already accounted for within the bamboo plank flooring and CLT data sets of the Tally® database and is even stated in the report exported from the application that both CLT and Bamboo plank flooring are inclusive of all associated materials i.e. adhesives, wood/bamboo, finishes etc.. This extra adhesive material would be added to the bamboo plank flooring if it was being used for its intended purpose as a flooring material where joints or base of the material would be adhered to one another or to a sub-floor. However, due to the nature of its use here this material can be excluded from the data.

[12] The LCA of all elements; walls, floors, doors, windows, foundations etc.

With this deduction taken into account and removed from the original results it makes the design option utilising laminated veneer bamboo marginally more favourable in terms of GWP. Interestingly the overall GWP is marginally lower in the LVB construction design option than in the design option with CLT by 331 kgCO_2e.

- CLT = 43,514 kgCO_2e
- Bamboo = 43,183 kgCO_2e

3.4.3 Impact of Adhesives

In a study by Y. Xiao, R.Z. Yang, B. Shan on the production, environmental impact and mechanical properties of Glubam structural elements, the energy consumption and carbon emissions of the resin used are evaluated;

- For the resin, a total of 22.5 MJ of energy is consumed when 1 kg phenol formaldehyde resin (PF) is produced.
- For epoxy resin adhesive, 25 kg is estimated in post-processing of 1m3 Glubam structural components. With 139.3 MJ energy per kilogram, a total of 3483 MJ energy is consumed from epoxy resin adhesive for 1m3 Glubam product.

Phenol formaldehyde resin and electricity are the main sources of the energy consumption for producing Glubam or plybamboo sheets. Therefore, the development of more eco-friendly resin and reduction of electricity usage would be the most efficient way to further reduce energy consumption of engineered bamboo production. (Xiao, 2013)

P. van der Lugt et al show in their study that the use of resin or adhesive has a relatively small contribution to the environmental impact of bamboo products, 3-21% of the eco-burden, depending on the product. A suggestion is made by van der Lugt et al that an improvement be made to the amount of formaldehyde free resin used in the products such as a synthetic, Emulsion poly Isocyanate (EPI), with a relatively low environmental impact or swapping to a fully biobased resin. This however, could have an effect on the structural capabilities and the substitution of a less effective biobased adhesive might not contribute to a better product. (Vogtander & van der Lugt, 2014)

This being said, in a study by Muttil et al (2014) evaluating the bond strength of formaldehyde and soy based adhesive in wood fibre plywood results showed that a "*soy based adhesive with agents like phenol...is much stronger than a plywood sample made from a formaldehyde-based adhesive*." The plywood samples were prepared to required sizes (100mm x 50mm x 1mm) and then tested for their modulus of rupture. Modulus of rupture (also known as flexural strength) is a mechanical characteristic for evaluating the strength of wood based materials like plywood. (Meier, 2015)

"The soya-based adhesive that was developed was found to have a higher modulus of rupture than the petroleum-based urea-formaldehyde adhesive. In addition to being stronger, plywood's using such biobased adhesives are free of the harmful formaldehyde emissions (a known carcinogen) released from traditional plywood, particleboard, and other composite products." (Muttil et al., 2014)

3.4.4 Conclusions and Discussion

The raw material growth cycle is taken into account for the cradle to grave life cycle. The bamboo (Phyllostachys Pubescens) growth cycle differs vastly from that of timber (spruce) by a factor of six. However, the results do not seem to display the great difference in growth patterns. The fact that bamboo grows quicker should have an effect on the GWP within this system however, the LCA results do not display the benefits of selecting a material with the ability to absorb and store carbon or its rate of growth

It has been outlined from correspondence with the application developers that embodied carbon is not accounted for within the Tally® application. With this in mind the growth cycle would potentially not actually have any major effect on the results as the advantages of rapid growth and storing large quantities of CO_2 are in effect not accounted for by the cradle to grave life cycle system, a major issue with the LCA modelling system. The data presented by the Tally®

Application only considers the carbon output from processes which contribute to GWP i.e. it calculates the energy demand and subsequent CO_2 output of extracting, manufacturing and disposing of a specified material. It does not factor the potential positive 'green value' of the material.

3.5 Carbon Sequestration

Bamboo minimises CO_2 and generates up to 35% more oxygen than the equivalent stand of trees.

- 1 hectare of bamboo sequesters 62 tonnes of CO_2/Year
- 1 hectare of young forest sequesters 15 tonnes of CO_2/Year (Janssen.J, 2013)

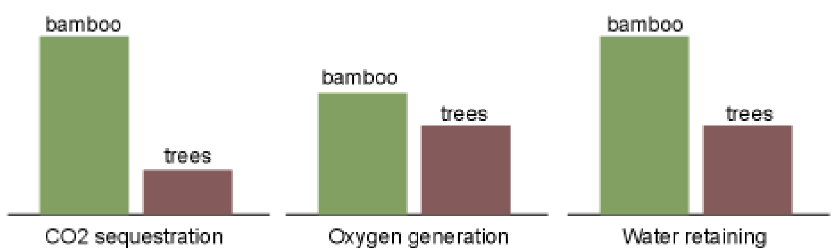


Figure 22: Bamboo v's Trees CO_2, O_2 & water retention(Janssen.J, 2013)

Bamboo extracts CO_2 from the atmosphere in a similar way to trees, through the process of photosynthesis. By using carbon as an energy source and converting it into plant tissue it releases oxygen (O_2) as a by-product.

Another property that makes bamboo more beneficial is the fact that the entire root system does not need to be disturbed when raw material extraction takes place. Poles or clums are simply cut at the base and allowed to regrow. This is beneficial in the sense that after the growth of bamboo it requires CO_2 as a food source to regenerate the carbohydrates lost in the felling of the crop. This means a higher amount of CO_2 will be absorbed directly after felling due to the root system remaining in place.

P. Van der Lugt et al (2014) argue that the burning of fossil fuels and deforestation coupled with a lack of afforestation has a dramatic effect on the global carbon cycle. It is of course naive to say that by substituting a greener alternative such as timber or bamboo will dissolve or greatly improve global warming potential and CO_2 sequestration. Vogtander and van der Lugt state simply:

> *"One should realise that, if there is no change in the area of forests and no change in the volume of wood in buildings, there is no change in sequestered carbon on a global level and hence no effect on carbon emissions. This means that only when more carbon is being stored in forests (either by area expansion with an increase of net carbon storage on that land, or by increased productivity in existing forests by improved management), and when the total volume of wood in buildings is increasing, there will be extra carbon sequestration."(Vogtander & van der Lugt, 2014)*

The authors go on to draw comparisons with the afforestation and reforestation in Europe, North America and China due to an increase in wood and bamboo used in buildings: "The conclusion is that carbon sequestration is enhanced when…softwood…and/or bamboo is applied in buildings." (Van der Lugt, 2014)

Continuing on with the theme of carbon sequestration the authors go on to deal with an in depth calculation of carbon storage in forests, plantations and building. The calculations outline a series of five steps to calculate the carbon sequestration if bamboo products are applied to the building industry and also carbon sequestration caused by land-use change. Steps are as follows:

- **Calculation of the carbon ratio**

This is the relationship of carbon stored in forest/plantations to that stored in the end product.

- **Calculation of the land use change correction factor**

This is a calculation to cope with a case if there was a previous type of biomass located on the area before changed to a forest or plantation

- **Calculation of extra stored carbon in forests and its allocation**

This is a factor accounting for the carbon sequestration increase due to the rise in the market for bamboo/timber products thus resulting in afforestation and the reforestation of land. In turn this will allow for greater carbon sequestration. This is presented as a more realistic way to account for temporary carbon storage which is the current best practice outlined by ILCD Handbook (The International Reference Life Cycle Data System Handbook)

- **Calculation of extra stored carbon in Buildings**

This relates to "application losses" estimated as 10% as defined by Van der Lugt et al (2014).

- **Final calculation of the total result**

As stated: Overall effect calculated by the multiplication of steps 1, 2, 3 and by adding step 4

The authors outlines the characteristics of bamboo which make it superior to woodland forests for afforestation and expanding plantations can result in a rise of CO_2 sequestration. These characteristics include:

- Rapid Growth
- Ability to plant in locations woodland would not be able to grow (degraded slopes)
- Root systems need not be disrupted at felling stage (no loss of ecology or biodiversity)
- Higher reforestation rate in China with bamboo than in Europe with softwoods due to market growth of bamboo.

When inspecting from a global carbon cycle perspective it is made clear due to the points listed previously that cultivating bamboo can be a promising solution to a more "sustainable, biobased economy based on renewable resources" (Lucas & IUFRO, 2015)

Furthermore, within the benchmark test, bamboo is specified to be sourced from China to an unknown final destination and this may result in further discrepancies between the results. CLT does not specify a source destination or a final destination. For this reason transportation is again highlighted as an unknown quantity. The data associated for transportation is an industry standard, an average. The data accounts for the average eco-cost and environmental burden for transportation of raw material to a product manufacturing site. The transportation from manufacturer to building site is not accounted for within the system boundary.

3.6 Transportation

Transportation of goods and its environmental impact is far beyond the scope of this research yet has a big impact on the life cycle of a material or product. In relation to sourcing bamboo from Vietnam or China a large quantity of the CO_2 emissions and overall environmental impact will be caused by the burning of fossil fuels in the transportation of the material to Europe from these areas of the world.

In the study by Van der Lugt et al this is the second highest contributor to eco-cost (28-37%) and carbon footprint (15-25%) depending on the material which is transported. Unavoidable for the European context, it is suggested that bamboo could be sourced closer to the location of use in areas such as Ethiopia or Central Africa reducing the effect of transportation by sea freight to Europe.

Local transportation contributes to approx. 10% of the eco-burden (Vogtander & van der Lugt, 2014)

This figure, whatever it may be, will be constant and unavoidable and will likely contribute negatively towards the overall GWP of LVB and hence its integration into designs and buildings in Europe. In another study conducted a Delft University, Netherlands, by Vogtländer et al, (2010) transportation of bamboo poles from Shanghai harbour to Rotterdam harbour in the Netherlands contributed to 89% of total emissions. (Joost Vogtländer, 2010; van der lugt, Vogtlander, van der Vegte, & Brezet, 2012)

In this study Vogtländer et al (2012) measured emissions in terms of eco-cost. The eco-cost of a material is a measure to express the amount of environmental burden a product or system has. It is represented in terms of Euros per kilogram (€/Kg) and in simple terms is the amount of money that would need to be invested in renewable technologies or environmental strategies to mitigate the CO_2 emissions of the material tested.

The results from the report by Vogtländer et al (2012) can be seen in table 10 Below.

Environmental impact assessment of carbonized 3-layer Plybamboo board					
Process step	**Amount**	**Unit**	**Eco-cost (€)/unit**	**Eco-cost (€)/ Functional unit**	**Eco-cost (€)/kg**
Transport from plantation to strip manufacturing facility; Eco-costs of a 5-ton truck (transport of 92.4 FUs)	30	Km	0.243/km per 5 ton truck	0.316	0.0075
Transport from strip manufacturing facility to factory; Eco-costs of a 10-ton truck (transport of 310.4 FUs)	600	Km	0.32/km per 10 ton truck	2.474	0.059
Transport from factory to harbour; Eco-costs of a (28-ton truck)	3.13	ton.km/FU	0.033/ton.km	0.1032	0.0099
Transport from harbour to harbour; Eco-costs (20ft container in a trans-oceanic freight ship)	200.24	ton.km/FU	0.0052/ton.km	1.0413	0.0999
Transport from harbour to warehouse; Eco-costs (28-ton truck)	1.2	ton.km/FU	0.033/ton.km	0.0396	0.0038

Table 12: Transportation Environmental impact (Eco-Cost) (Vogtländer et al 2012)

The eco-cost of shipping equated to 25% of the total environmental burden of 3-layer plybamboo. Adding this to the other transportation steps in the process that equate to 20.4% the total contribution is 45.4%. This highlights that the carbon emissions due to transportation are still a major contributor to the overall global warming potential of bamboo products.

However, newer more efficient proposals for transporting goods, in particular one for a 'New Silk Road' Railway from 'east to west China, routed through Kazakhstan, Russia, Belarus, Poland, Germany, France and finally to Spain' (Dispatch, 2014) present an interesting argument that if transportation of goods becomes more efficient and produces less pollution then the overall contribution of the transportation stage to carbon footprint can be reduces This efficient manner of acquiring goods will have an beneficial effect on the time frame of a project resulting in better, cheaper more efficient building projects and potentially lower carbon emissions. However, this area requires further specialised research.

Benchmark Test and LCA Literature Review Comments

The use of the Tally® application within Autodesk Revit® has been proven as an option for calculating a life cycle assessment and in particular global warming potential (GWP).

The data that was extracted from the model was examined further and more comprehensively to ensure that the entire scope of the material is being accounted for. Assumptions and limitations will be outlined fully within the primary full scale test.

Furthermore, the treatment of biogenic carbon (carbon stored and sequestered during growth) is not accounted for within the scope of the life cycle analysis. It is assumed that this biogenic carbon is kept within the cradle to cradle scope of the analysis i.e. the carbon stored within the material is released again at the end of life and absorbed back into the system. However, this may not be the case as discussed in the report by P. van der Lugt et al on the treatment of biogenic carbon.

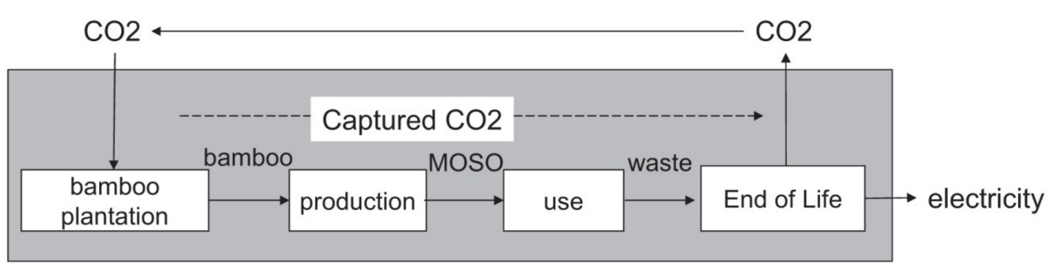


Figure 23: System boundary of MOSO bamboo (P. Van der Lugt)

This effectively makes the argument of superior CO_2 sequestration and CO_2 storage in relation to wood based products a questionable issue, due to different ways of treating embodied carbon and CO_2 sequestration. Embodied carbon is addressed however; CO_2 sequestration is an issue that is not particularly addressed fully when conducting a life cycle assessment. This statement is of particular interest when talking about 'green' natural materials that have the ability to store and absorb CO_2. Timber and bamboo are materials that find themselves in this category and may be portrayed in a way that does not fully predict the global warming potential which is produced from the LCA application.

As was stated by P. van der Lugt et al subjects concerning CO_2 sequestration e.g. afforestation, rapid renewal of plantations and an increase in forested land due to market growth are not accounted for within a life cycle study. Also **not** accounted for here is bamboo's ability to absorb and store large amounts of CO_2 in a reduced time compared to woodland.

Bamboo plantations have the ability to absorb as much as four times the amount of CO_2 as woodland (Janssen.J, 2013). (see section 3.5 for further information on this issue) Combine this with the shorter growth cycle, of 3-5years for bamboo species (Phyllostachys & Guadua) compared to 20-30years for certain wood species (spruce), the hypothesis is that, the difference in total carbon footprint between wood and bamboo should be much greater.

Due to the superior structural capabilities as evaluated by the tests reported on in the structural evaluation chapter (Section 3.0-3.5) the research now aims to explore an efficient method of implementing engineered bamboo products through a diaphragm building systems and carefully considered construction detailing. This system will then be evaluated as part of the life cycle assessment.

4.0 Case Study (Stadthaus, Murray Grove)

Completed in 2009, the multi award winning, Stadthaus at Murray Grove is a nine story residential building located in Hackney, just north of the city of London. Consisting of both private and affordable apartments it is, according to the cross laminated timber company KLH, the "pioneer of timber residential tower buildings in the world"(KLH, 2015). The entire structure comprises of 29 apartments.

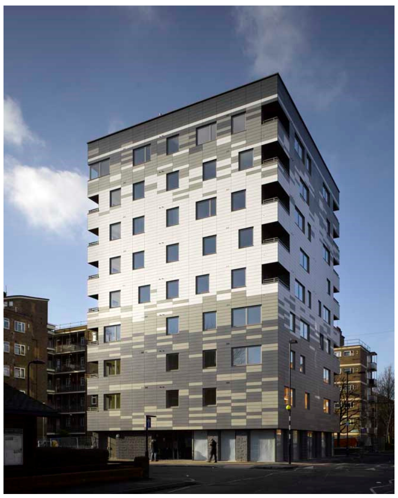


Figure 24: Case Study: Stadthaus, Murray Grove, London

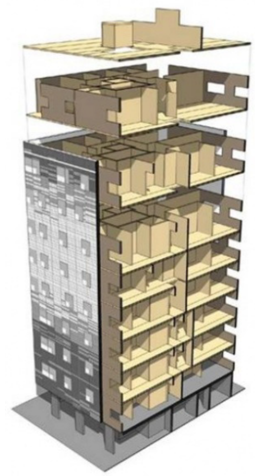


Figure 25: 3D Cross section of Stadthaus

Figure 26: Internal view of CLT construction at Stadthaus

The entire tower is constructed using a series of Cross Laminated Timber panels produced by KLH which "form a cellular structure of timber load bearing walls" and "timber floor slabs" (KLH, 2015).

Stadthaus is currently one of the tallest habitable residential timber buildings in the world. Through the selection of timber as the primary construction material the design team were able to reduce the carbon footprint of the building in a number of ways.

"The designers calculated that had the building been of conventional reinforced concrete construction, it would have incurred an additional 124 tonnes of carbon generated during construction. Adding this to the 188 tonnes of carbon sequestered (locked away)(during

the growth of the tree) *in the 900m³ of timber in the structure results in a total offset of some 310 tonnes of carbon." (TRADA, 2009)*

This offset allowed for the planning authority to grant a dispensation from the 'Merton' rule which usually requires that 10% of the energy for the building and its occupants be generated on-site using renewable energy equipment. (Merton, 2015) (This rule has since been superseded by new amendments to the building regulations under Part L.)

Furthermore, the speed of construction using this method of cross laminated timber is also worthy to note with regards to the installation cost and emission caused during this phase as part of the life cycle assessment of the building. The entire super structure was erected within 27 working days. The entire building programme for the CLT build was 49 weeks, 7 weeks of which were for the erection of the CLT superstructure, 23 weeks shorter than if an equivalent concrete building had been constructed (KLH, 2015). This rapid building process again results in a positive outcome when it comes to the energy and carbon emissions associated with building construction.

While laminated veneer bamboo is a different material it will benefit similarly to the construction methods already established for cross laminated timber. The methods of construction will be evaluated in the chapter to follow. Also, due to the structural capabilities established in the structural review chapter Section 3.0 a diaphragm system will also be developed and assessed under the life cycle assessment.

5.0 Panelised Building System Design

For the purposes of this research a standardised panel system has been developed to compete with cross laminated timber (CLT) panels. The initial panel system as seen in the images (Figure 27 & 28) below utilised laminated veneer bamboo (LVB) ply sheets in an efficient manner to exploit the structural characteristics of LVB ply. This system was designed to be a series of interlocking pieces which could be efficiently cut using CNC and assembled either on site or in factory controlled setting and then transported to site fully assembled. Panels are glued and screwed to ensure a strong connection is made between each of the elements.

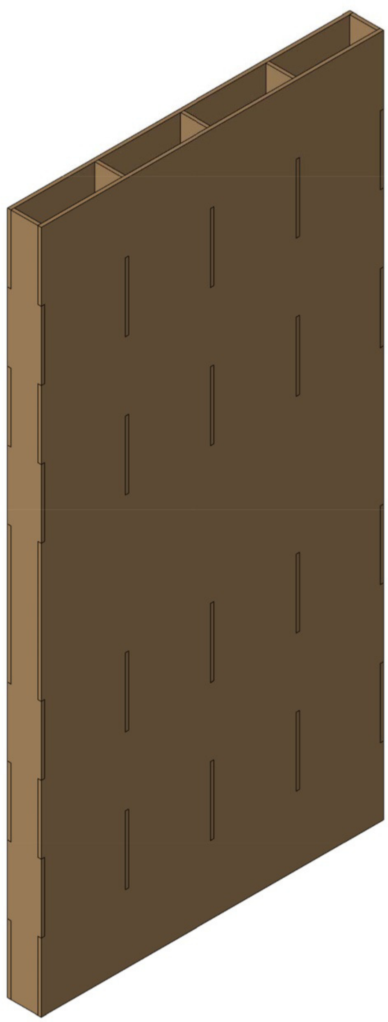


Figure 27: First design - Laminated veneer bamboo Panel System

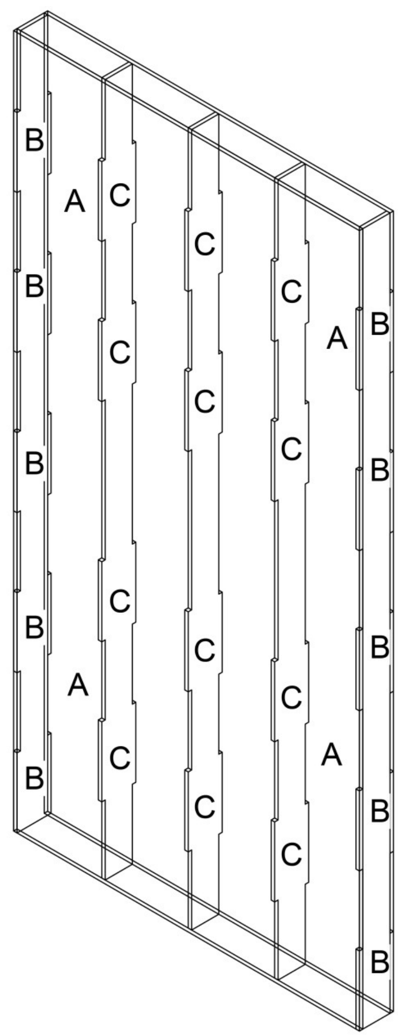


Figure 28: First design - Laminated veneer bamboo Panel System (Wireframe)

Each panel comprises of two full 2440mmx1220mm sheets (A) with studs or 'ribs' (B &C) placed at regular intervals in between the two sheets. Each panel was designed to efficiently use a 2440mmx1220mm sheet. Figure 29&30 below show the cutting setup for each sheet that is required to assemble a single panel. Table 11 shows a breakdown of the parts required.

Table 13: Initial panel design parts breakdown

Criteria	Part A	Part B	Part C
Number Required per panel	2	2	3
Number of piece available per single 2440x1220 sheet	1	4	4

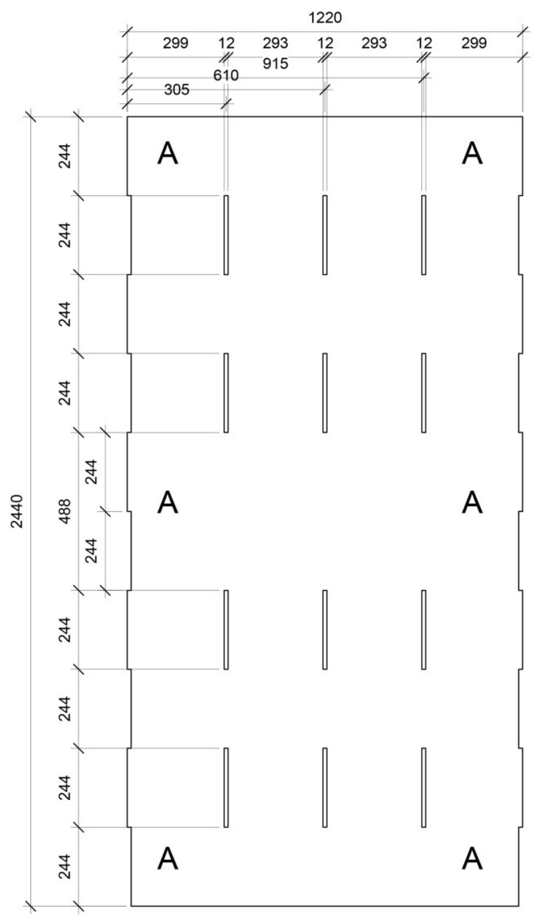


Figure 29: Sheet A - First design panel concept

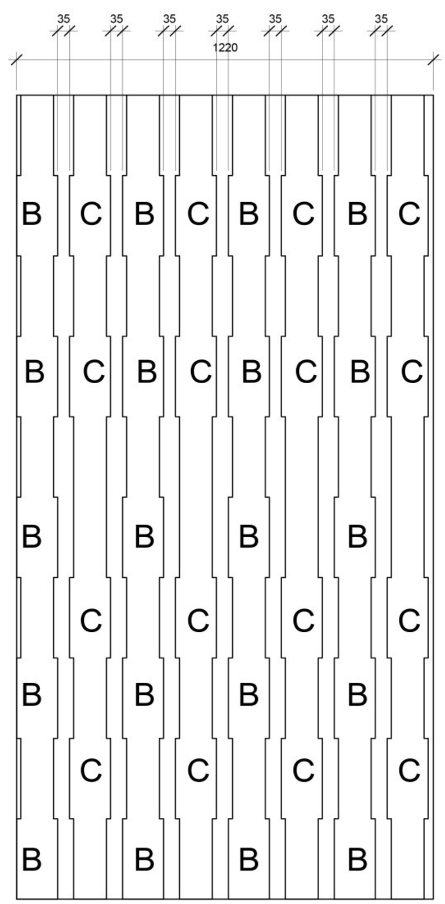


Figure 30: Sheet B & C - First design panel concept

Based on the comments by the specialist advisor and engineer, John Lauder, changes were made to the design of the panels. The changes are listed below:

- Panels are now designed without joints. Comments were made suggesting that the joints were not particularly necessary to ensure a connection between elements
- The thickness of the studs or 'ribs' was increased from 12mm to 24mm. This was done to ensure there was no cracking or damage to the stud as the screw connection is made. Panels are now designed with pilot holes for screws and changes have been made to the thickness of the studs.
- Suggestions were also made to include a certain amount of bridging between the studs to minimise the potential buckling effect and provide the panel with extra rigidity.
- Completely enclose panel system with a footing piece and top capping piece. These like the studs will be 24mm thick and 1220mm long to fully enclose the panel. By placing a capping piece and a footing the overall height of the panel is increased to 2488mm (2440mm+24mm top and bottom).
- The main face sheets (A) remain at 12mm thick.
- Comments were also made that panels should not be restricted to a height of 2440mm.

Revisions to the panels can be seen in figure 32 & 33.

5.1 Proposed Testing of Concept Panels

Based on the concept designs it was the intention of the research team under the supervision of engineering experts to conduct a series of test on the mechanical properties of the panels designed in this section. In particular the panels were to be tested under compressive strength, tension, shear strength flexural strength and modulus of elasticity. Each test was to be conducted on a number of panels (10 per test) and the results complied and presented as part of this report. Meetings took place with Bamboo suppliers of Ireland in Peamount, Dublin to supply the laminated bamboo sheets and contact was made with a fabricator to cut and assemble the sheets into test panels. The fabrication was outsourced from DIT as the CNC machine and facilities were too small to cut full 1220x2440mm sheets. Furthermore, facilities to conduct the tests were explored and booked on-site at DIT Bolton Street under the supervision of David Thompson who was being recruited to the research team to assist with the testing of the panels and ensure the right measures and standards were met for the intended tests.

The results of these tests would have made a major contribution to this research determining the mechanical properties of a panelised engineered bamboo building system. The results of these tests could in turn have been inputted into the life cycle analysis conducted here to better inform readers of the full potential of LVB panelised structures.

However, developments within the research have allowed us to partner with Arups, a consulting engineering firm, to provide comments and observations on the potential of the system panel. Comments to follow are from a meeting on the 14/09/2015 with David Madden, structural engineer at Arup Dublin, and a series of emails with Sebastian Kaminski, Senior Structural Engineer at Arup London, over a 10-day period beginning Friday 18/09/2015. The full extent of the conversations and comments made by the two structural engineers can be found in the appendix. The following is a summary of the comments made by Madden and Kaminski (September 2015)

- Initial thoughts and views of the structural engineers were that the figures and data may be misleading and possibly incorrect
- On inspection strength values for raw bamboo, engineered bamboo and other species appeared ‘High’
- Studies used may not be using similar characteristic strengths
- If they are a health safety factor needs to be applied for use.
- For use; a suggestion is made that an assumption be made that LVB has similar mechanical data to Douglas-Fir LVL

Along with these comments send in emails it was also suggested that it could be possible to use a mix of panel designs to achieve a structurally sound building. At the lower levels (1st floor-5th

Floor) a solid panel could be used much like the CLT currently applied in Murray Grove. However, at the upper floors (Floor 6th floor-9th floor) the diaphragm system could be applied. Suggestions were also made to increase the face sheet of the panel to 24mm thick LVB ply to increase rigidity in the panel. These comments suggest physical testing is required to acquire appropriate mechanical properties of the panel system presented. The revised panel designs can be seen in figure 32 & 33.

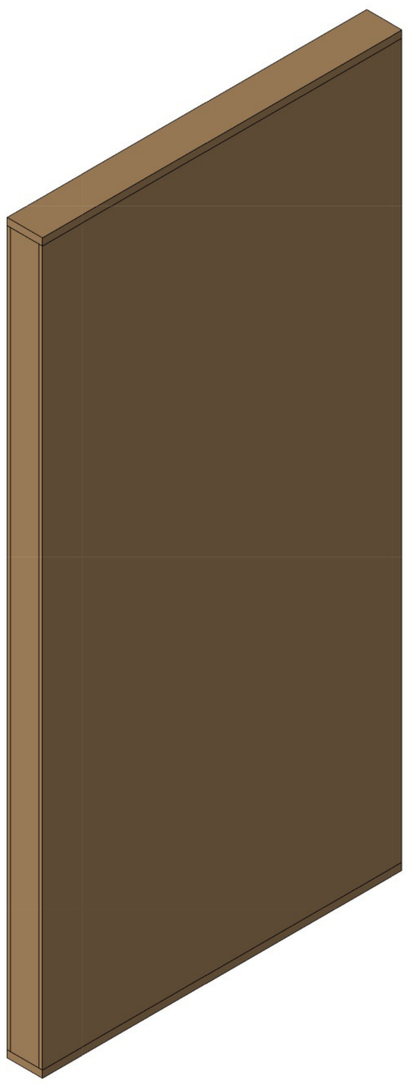


Figure 31: Laminated veneer bamboo Panel System

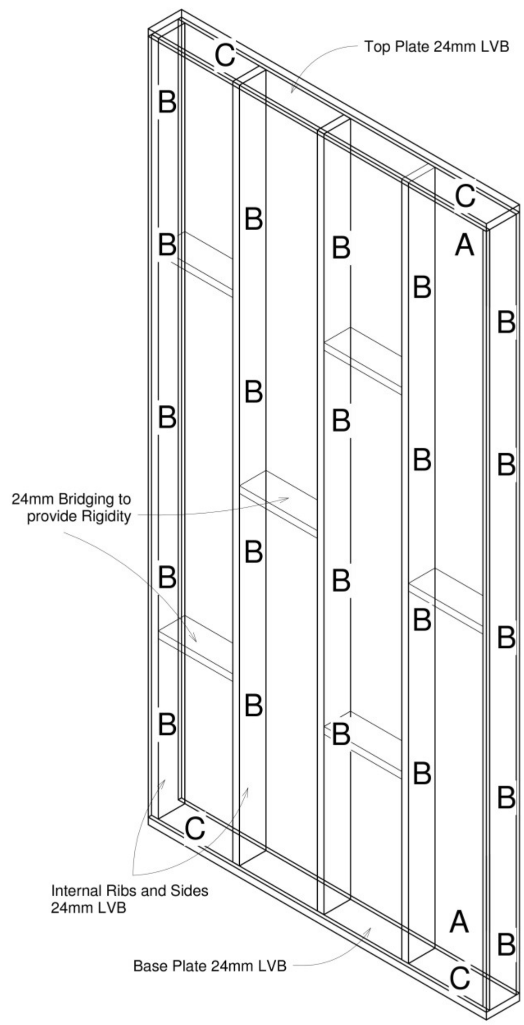


Figure 32: Laminated veneer bamboo Panel System (Wireframe)

The revised panel designs much like the first concepts are each made up of two full 2440x1220 sheets with studs or ‘ribs’ placed at regular intervals in between the two sheets. The panel has a 1220x120x24mm footing at the base and is capped with a similar head piece to completely enclose the panel. The images (figure 34 & 35) below show the parts required to assemble the panel system.

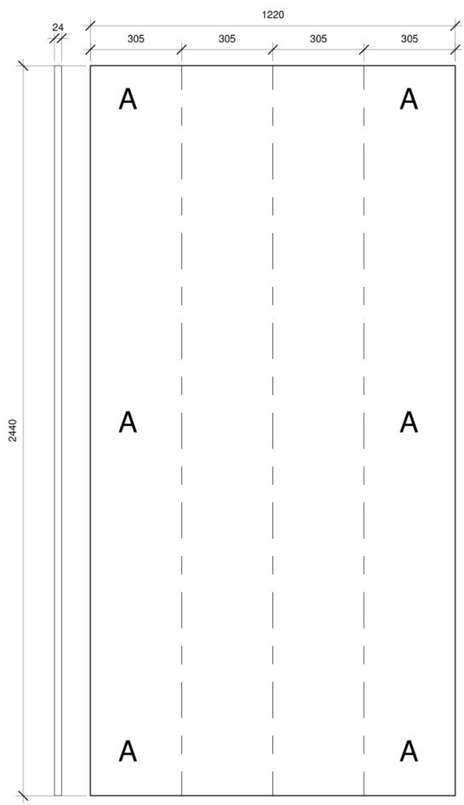


Figure 33: Sheet A LVB Panel System

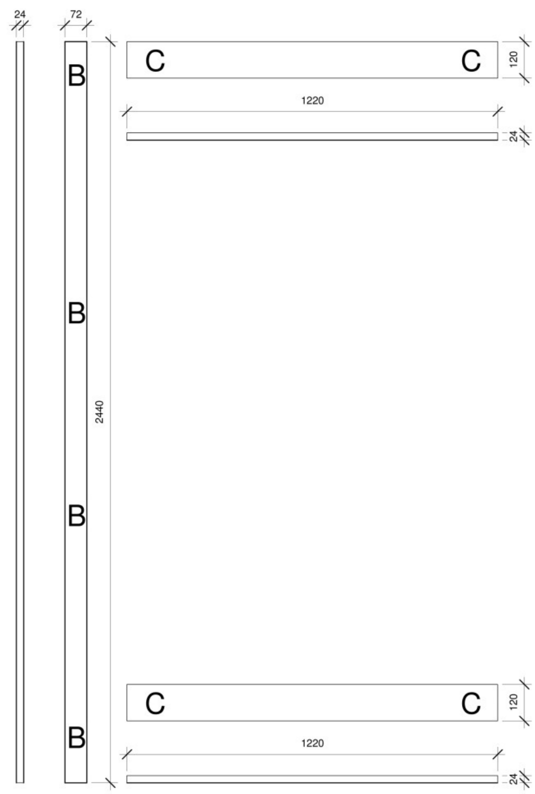


Figure 34: Stud/Ribs (B) and Top cap and footing (C)

The requirements for each one of the panels can be seen in table 12 below:

Criteria	Part A	Part B	Part C
Number Required per panel	2	5	2
Number of piece available per single 2440x1220 sheet	1	9	18

Table 14: Revised panel System parts breakdown

5.2 Construction Details

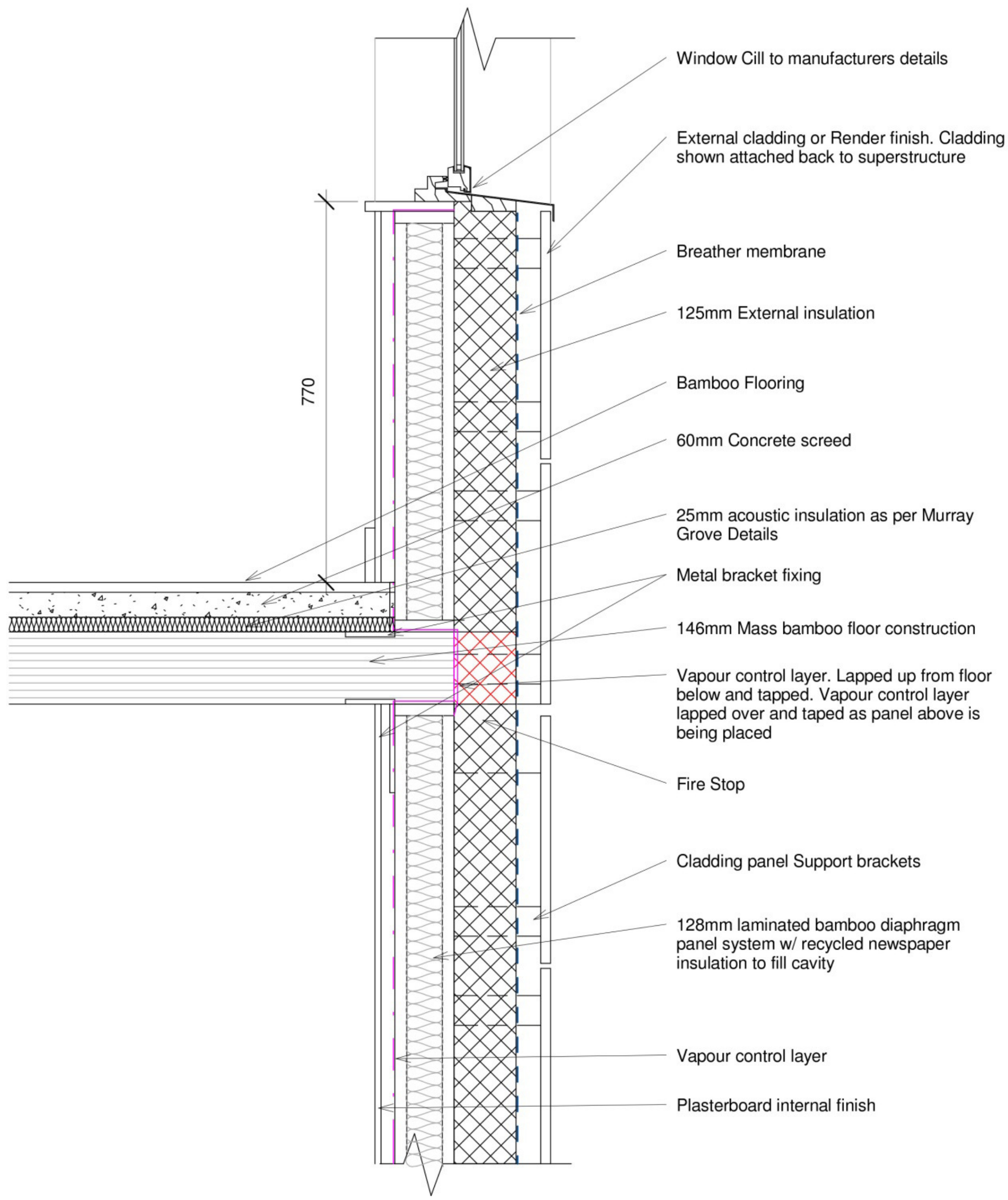


Figure 35: Construction detail A (not to scale) (Window Cill & Mid floor Junction) for LVB Panel system

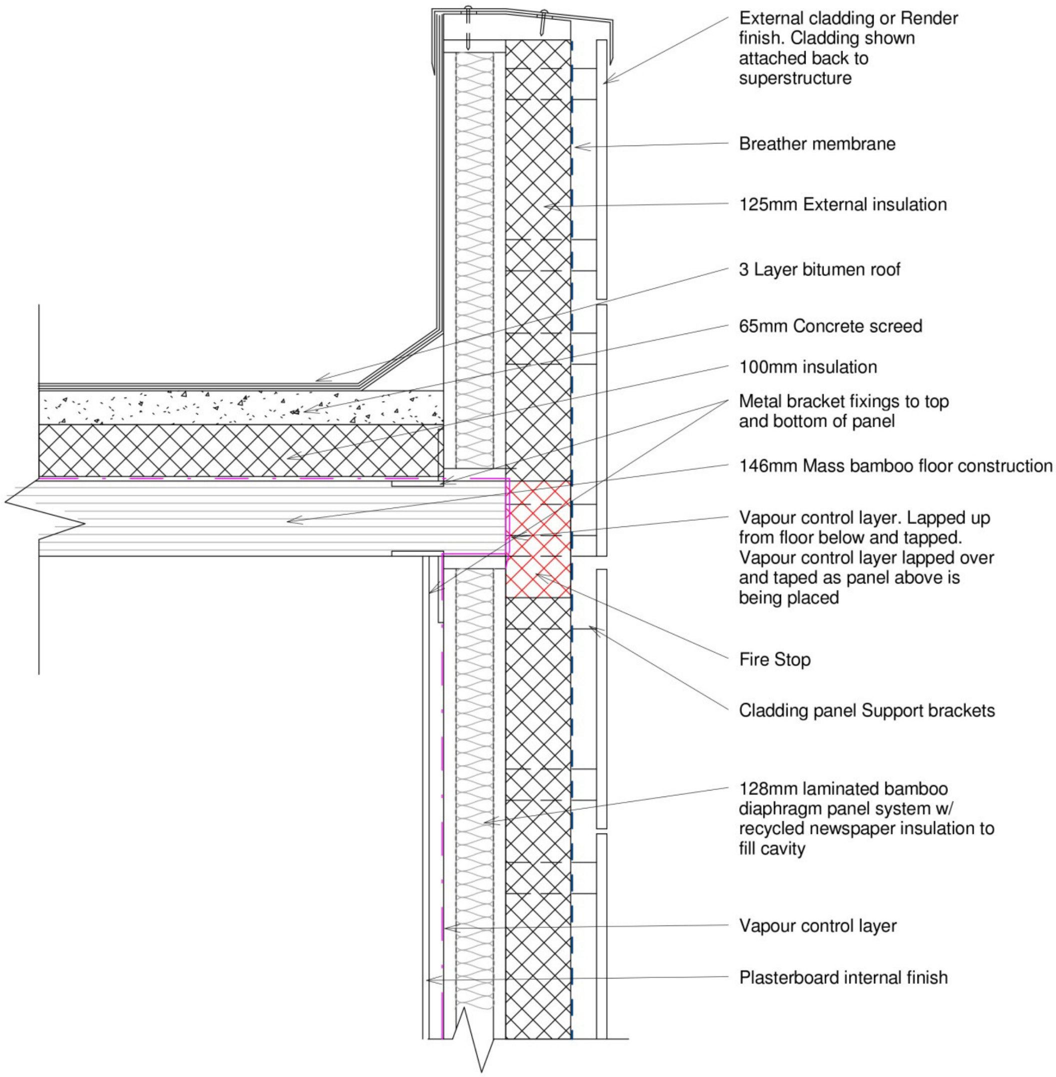


Figure 36: Construction Detail B (Not to Scale) (Parapet) for LVB Panel System

7.0 Primary Life Cycle Analysis

7.1 Scope

The scope of this study is to determine the global warming potential, through life cycle analysis, of laminated veneer bamboo diaphragm construction panels against that of cross laminated timber panels for use in high density high-rise residential accommodation.

7.2 Definition of Goal/Product system

As stated previously the main goal of this study is to determine the global warming potential[13] of laminated veneer bamboo diaphragm construction panels over the selection of cross laminated timber panels. The following report is set up to the standards set out in ISO 14040 and the LCID handbook.

Using the Stadthaus at Murray Grove case study for high density high-rise residential accommodation, laminated veneer bamboo diaphragm (LVBD) panels have been substituted as an alternative to Cross Laminated Timber (CLT) panels (see design details and concept design from previous chapter section 5.0). The product system to be studied, as mentioned in the goal of the LCA, is an application of LVBD Panels through a Cradle to Grave life cycle. The study will compare the application of LVB Panels to the current CLT option that has been utilised in Stadthaus, Murray Grove.

The life cycle testing is conducted on a full building model. As per the benchmark test conducted previously (see studio benchmark test chapter section 3.4.2) the testing is undertaken using an application, Tally®, in conjunction with Autodesk Revit®. This application utilises reliable life cycle databases set up by PE international (now 'thinkstep'). Thinkstep is a provider of "the most comprehensive source of sustainability data in the world" with "72,000+ constantly evolving datasets compiled over 20 years". (Thinkstep, 2015) It provides the world's most up to date and reliable LCA data. The reason for selecting this platform to conduct the LCA was that

[13] **Global Warming Potential (GWP):** (kg CO_2 eq) A measure of greenhouse gas emissions, such as CO_2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health, and material welfare.

it could be easily used in conjunction with a Revit®. By utilising skills in Revit the LCA application could easily take modelled materials and volumes from the Revit Families created for the projects and life cycle data could easily be applied to them in Tally®. Other applications like Gabi and Ecoinvent were explored and could have been used to conduct this study. However, the simplicity and ease of use of Tally® in Revit® was the reasoning behind its selection.

7.3 Product description

7.3.1 Laminated veneer bamboo (LVB) is a product that uses multiple thin strips of bamboo combined with an adhesive to form a board or sheet product. (For full manufacturing process see 2.1.1) Evaluated in as recently as 2007 for structural use by ASTM international it has since been added to their standards. Currently manufactured to desired specification, sheets are typically manufactured to standard sizes of 1220x2440mm and are available in a range of thicknesses from 3mm upwards. Due to this fact panels are restricted to a standard size of 1220mmx2440mm. However, it has been highlighted that this restriction in height and length could be overcome simply by increasing sheet sizes to 3000mm-3500mm to accommodate the intended purpose or application. This increase would be used to facilitate a higher floor to ceiling dimension. As can be seen from the structural literature review (Section 3.0) previously, the mechanical properties of LVB outweigh those of timber board products by a considerable amount.

Utilised until now predominantly as a decorative material or as a material for purposes other than primary structure there has recently been a major rejuvenation in research evaluating its potential for structural applications. Many of these studies highlight that LVB is underutilised for the purpose of a primary structural material.

Figure 37: Laminated veneer bamboo Ply board (Lamboo, 2012)

7.3.2 Cross-laminated timber (CLT) is a mass wood based product, developed in Switzerland in the early 1990s, designed for increased dimensional stability and strength in framing systems. CLT is an engineered wood panel typically consisting of three, five, or seven layers of dimension lumber oriented at right angles to one another and then glued to form structural panels with exceptional strength, dimensional stability and rigidity. (reThink, 2015)

"Green building practices have helped CLT's popularity, with its combination of environmental performance, sustainability, design flexibility, cost-competitiveness and structural integrity. As CLT is all wood (except the adhesive that binds it together), it offers carbon-storage advantages over non-wood structural alternatives." (wood, 2015)

A recent agenda for carbon neutral and near carbon zero building has seen a massive rise in the use of CLT in high rise construction, particularly residential and office building. Research projects such as 'Tall Wood' by Michael Green Architects, Canada and the Timber tower report by Skidmore, Owings & Merrill LLP (SOM), USA show that there may be a potential to build up to thirty stories tall utilising CLT and other Mass timber practices.

Figure 38: Cross Laminated Timber (Brettsperrholz, 2016)

7.4 Functional unit and reference flow

The functional unit is a measure of the function of the studied system and it provides a reference to which the inputs and outputs can be related. This enables the comparison of two essentially different systems. (ISO, 2013)

The functional unit of the analysis is the usable floor space of the building under study.

The reference flow is the amount of material required to produce a building, designed according to the given goal and scope of the assessment, over the full life of the building. It is the responsibility of the modeller to assure that reference buildings or design options are functionally equivalent in terms of scope, size and relevant performance. The expected life of the building has a value of 50 years as manually specified by the modeller. (Tally, 2015)

7.5 The System Boundary and delimitations

The system boundary of LVB begins with the extraction of bamboo and ends with the disposal of the material at the end of its life cycle **(Cradle to Grave).**

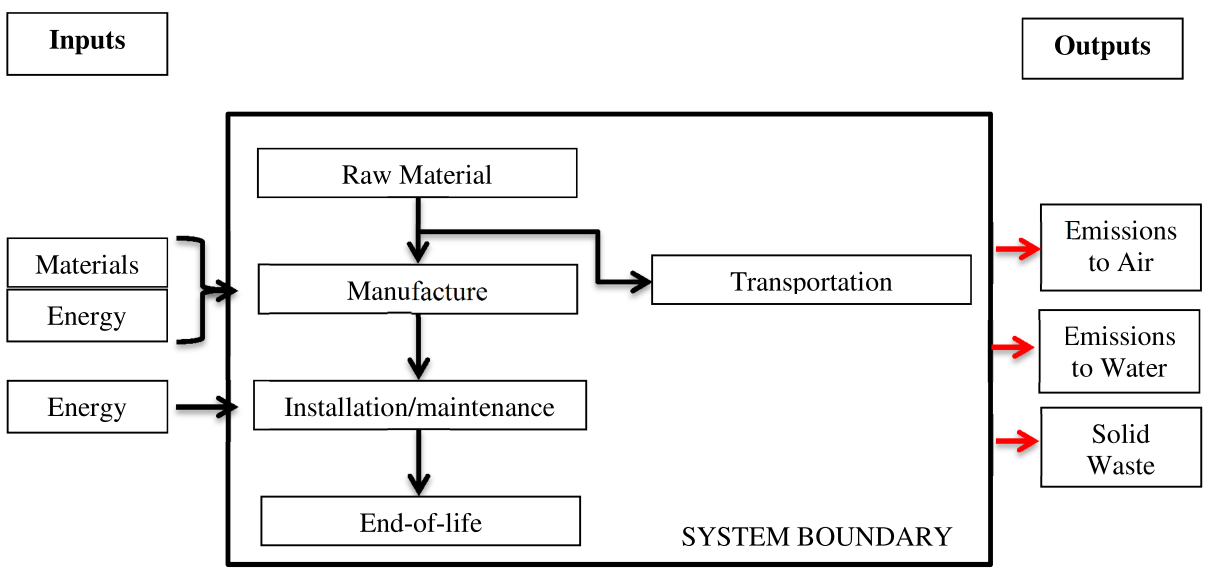


Figure 39: System Boundary for life cycle assessment

The manufacturing process includes all necessary life cycle data for the **cradle to gate life cycle stages** associated with the specific materials in the LVB and CLT design options.

The life cycle analysis (LCA) accounts for the full cradle-to-grave life cycle of the design options studied, including

- Material manufacturing,
- Maintenance and replacement, and eventual
- End-of-life (disposal, incineration, and/or recycling), including the materials and energy used across all life cycle stages.

Architectural materials and assemblies include all materials required for the product's manufacturing and use (including hardware, sealants, adhesives, coatings, and finishing etc.) up to a 1% cut-off factor by mass with the exception of known materials that have high environmental impacts at low levels. In these cases, a 1% cut-off was implemented by impact.

Manufacturing includes cradle-to-gate manufacturing wherever possible. This includes

- Raw material extraction and processing,
- Intermediate transportation, and
- Final manufacturing and assembly.

Due to data limitations, however, some manufacturing steps have been excluded, such as the material and energy requirements for assembling doors and windows. The manufacturing scope is listed for each entry, detailing any specific inclusions or exclusions that fall outside of the cradle-to-gate scope.

Transportation of upstream raw materials or intermediate products to final manufacturing is generally included in the GaBi datasets utilized within this tool. **Transportation requirements between the manufacturer and installation of the product, and at the end-of-life of the product, are excluded from this study.** However, the eco-cost of transportation has been evaluated previously in the benchmark test chapter (Section 3.4.2)

Infrastructure (buildings and machinery) required for the manufacturing and assembly of building materials, as well as packaging materials, are not included and are considered outside the scope of assessment.

Maintenance and replacement encompasses the replacement of materials in accordance with the expected service life. This includes;

- The end-of-life treatment of the existing products and,
- Cradle-to-gate manufacturing of the replacement products.

The service life is specified separately for each product.

End-of-life treatment is based on average US construction and demolition waste treatment methods and rates. This includes

- The relevant material collection rates for recycling,
- Processing requirements for recycled materials,
- Incineration rates, and
- Landfilling rates.

Along with processing requirements, the recycling of materials is modelled using an avoided burden approach, where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material. Incineration of materials includes credit for average US energy recovery rates. The impacts associated with landfilling are based on average material properties, such as plastic waste, biodegradable waste, or inert material. Specific end-of-life scenarios are detailed for each entry (Tally, 2015). Being a US company that develops the LCA tool European methods and rates were not available within the package. Thus, US rates were applied to the life cycle study.

7.6 Procedure

The following is an outline of the procedure undertaken to conduct the life cycle test. It includes the process of completing the Revit© Model and its subsequent use with Tally© life cycle software. The materials and definitions will also be outlined in this chapter and all assumptions and associated life cycle data will be clearly defined.

In order to conduct a life cycle with Tally® a 3D Revit® model must first be constructed and the modelled data and information extracted. Due to the convenience of using the two programmes together all data can be easily shared between the two. Data extracted from the Revit model to Tally includes:

- Materials
- Quantities
- Volumes
- Areas
- Weight

The entire model was built using simple components (Families) also designed and modelled within Revit®. For a full description of the procedure for the panel design can be found in the concept/design chapter (Section 5.0). A full list of these families can be viewed in the LCA report exported from Tally® in the appendix.

Using a similar process as the benchmark test two design options were modelled in parallel. Option A was constructed with laminated veneer bamboo (LVB) as the primary structural material while in Option B cross laminated timber (CLT) was designated as the primary structural material.

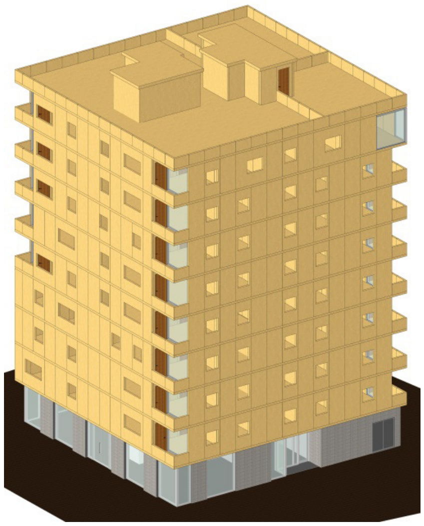


Figure 40 Cross laminated timber Design Option

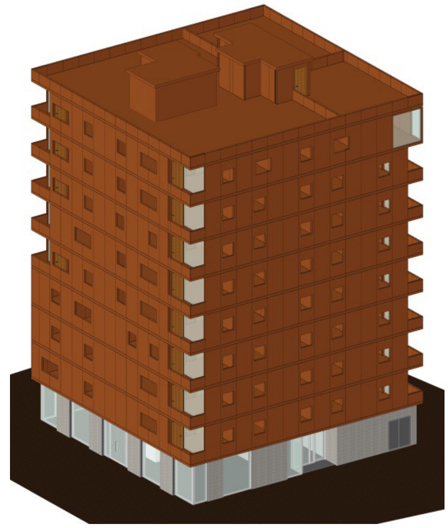


Figure 41 Laminated veneer bamboo Design Option[14]

It is of the utmost importance that the Revit® model is built with careful consideration as all values and quantities depend on the accuracy of the modelled elements.

The model of Stadthaus, Murray Grove, was constructed using a planning file submitted to Hackney council. (Planning application No. 2007/0988) Contact was made with Waugh Thistleton Architects to seek permission and information on the building. Though no additional information was received, an interest in the project was stated from the correspondence.

The following outlines the elements included and those excluded from the Revit® model:

- For the purposes of this study **only the primary structural elements** where modelled. No secondary elements or finishes where applied to the model to ensure consistency. There is a large proportion of the as-built building not included in these models as this is a study on the structural building elements. And for that reason a portion of the overall impact of the overall building is not measured. **Only the structural elements were being tested in this LCA. Any other elements included are listed below.**

[14] Figures 41/42 above show 3D view of Revit® models created for Stadthaus, Murray Grove. These two models are identical in nature and size with the obvious difference in structural material and building method (i.e. Solid CLT or diaphragm panel where stated.

- No windows have been included in the model. However, openings have been included in the panels based on the elevations of the existing planning drawings.
- Curtain wall glazing has been included at the ground floor and at balconies.
- Internal doors have been included. Some doors have been placed in the model as independent elements and will show up in the LCA report as independent elements. LVB or CLT panels have been modelled to include doors and have been labelled appropriately in the report to show this. Doors have been modelled identically in both the LVBD and CLT design options. The doors were included in the model in order to ensure the volume of material in the door panel be it LVB or CLT was correct. This same principle applies to the openings cut in the window panel types.
- In both the LVB and CLT design options:
    - Wall panel thickness = 128mm
    - Floor Thickness = 146mm
    - Lift core wall thickness = 300mm (mass CLT or Mass bamboo in the bamboo options)
    - Stair core wall thickness = 300mm (mass CLT or Mass bamboo in the bamboo options)
    - Roof thickness = 200mm

7.7 Impact Categories

The impact category under study in this LCA is Global Warming Potential (GWP). The global warming potential of a gas refers to the total contribution to global warming resulting from the emission of one unit of that gas relative to one unit of the reference gas, carbon dioxide, which is assigned a value of 1. This may also be commonly expressed as the 'Carbon footprint' of a material, product or unit output.(C. C. D. US EPA, 2001)

The GWP of a gas or substance depends on the timespan or what is more commonly known as the time horizon. Since GWP is measured over a prescribed period of time, in this instance 50 years, gases may be removed from the atmosphere at a fast rate thus initially having a large effect but, over prolonged time periods, as it diminishes, it becomes less important.

For instance, as can be seen in table 56 below taking carbon dioxide CO_2 as a reference value and assigning it a value of 1, methane is assigned a GWP of 56 over 20 years. However, this drops to 21 over 100 years. The same applies to nitrous oxide N_2O starting at a value of 280 over 20 years but increasing to 310 over 100 years before decreasing again to 170 over 500 years. See Table 13 below.

A full list of gases and substance and their specific contributions to GWP can be found in the appendix. (U.N, 2015)

Species	Chemical formula	Lifetime (years)	Global Warming Potential (Time Horizon)		
			20 years	100 years	500 years
CO_2	CO_2	variable §	1	1	1
Methane *	CH_4	12±3	56	21	6.5
Nitrous oxide	N_2O	120	280	310	170

Table 15: Global Warming potential of different Gases

7.8 Life Cycle Impact Assessment

The life cycle impact assessment (LCIA) phase defines links between the life cycle inventory results and the potential environmental impacts. (Puettmann, 2013) Figure 42 below is a graphic representation of the LCIA impact categories of the project. Highlighted in red is the Global Warming Potential. This image also shows a comparison in the values associated to CLT and LVB in relation to an LCA not under consideration in this research. They include:

- Acidification Potential
- Eutrophication Potential
- Ozone Depletion
- Smog Formation Potential
- Energy Demand
- Renewable and Non-renewable Energy

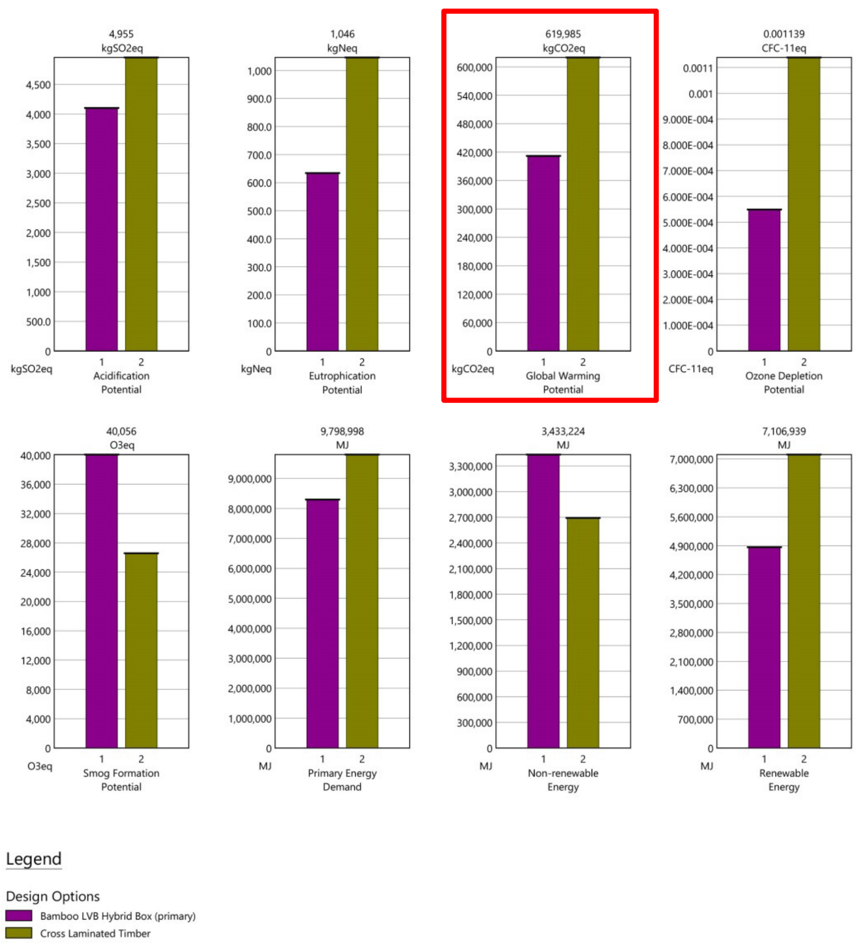


Figure 42: Comparison of impact categories for LVB and CLT Design options 12mm sheets x 128mm depth (Generated from Tally Application as a result of specification of materials)

Table 14 presents the environmental impact of the two design options based on the case study model of Stadthaus, Murray Grove. The values found in Table 14 are the total cumulative effect of all the process associated in implementing LVB or CLT. These associated impacts include:

- Forestry or bamboo plantation management
- Bulk commodity transportation
- Manufacture of products and all upstream process (energy required at manufacturing plant. glues, finishing, etc.)
- End of life impacts

Impact Category	Bamboo LVB diaphragm Box (primary)	Cross Laminated Timber
Sum of Mass Total **(kg)**	328,341	575,986
Sum of Acidification Potential Total **(kgSO2eq)**	4,103	4,955
Sum of Eutrophication Potential Total **(kgNeq)**	634	1,046
Sum of Global Warming Potential Total **(kgCO2eq)**	412,010	619,985
Sum of Ozone Depletion Potential Total **(CFC-11eq)**	0.0005	0.0011
Sum of Smog Formation Potential Total **(kgO3eq)**	40,056	26,588
Sum of Primary Energy Demand Total **(MJ)**	8,296,976	9,798,998
Sum of Non-renewable Energy Demand Total **(MJ)**	3,433,224	2,692,059
Sum of Renewable Energy Demand Total **(MJ)**	4,863,753	7,106,939

Table 16: Environmental impact of laminated veneer bamboo and cross laminated timber design options 12mm sheets x 128mm depth

Interesting to note is the higher values for the **sum of smog formation potential total** and the **sum of non-renewable energy demand total** in the bamboo LVB diaphragm box build. As part of the total primary energy demand also presented in the LCA results shown a section of that energy demand is deemed nonreplicable or replaced at a very slow rate by natural means (Jolliet, 2016). This non-renewable energy usually comes in the form of fossil fuels where in most cases energy dissipates in the form of unusable heat. As previously discussed, action could be taken to assign an eco-cost to all materials to reinvest in renewable resources to combat this issue. However, in the current situation it is noted as a factor against the use of engineered bamboo, a factor which is 41% for the bamboo LVB option compared to 27% for the CLT option. However, to counter this issue the overall primary energy demand of 8,296,976 MJ is circa 16% lower than the 9,798,998 MJ used in the CLT option. Similarly the sum of renewable energy demand is 58% of the total energy demand compared to circa 72% in the CLT option.

Also worth noting is the sum of smog formation potential. The bamboo LVB option contributes 33% more to this compared to the CLT option in this instance. Considering the effects that this can have on human health it is an issue that must be considered and explored fully. Further research needs to be conducted on these areas to assess the differences between the two systems and their overall impact. As stated previously for this study, the global warming potential will be the main area of focus.

The entry source data or the data that was used to conduct the LCA can be seen below. The entry source data is provided by Thinkstep (formally PE International) within the Tally® application. For this LCA the data can be seen for each design option on the page over.

Bamboo Diaphragm System:

CN: Bamboo (estimation) PE (2012)

GLO: Bulk commodity carrier PE (2012)

US: Heavy fuel oil at refinery (0.3wt. % S) PE (2010)

CN: Electricity grid mix PE (2010)

DE: Phenol formaldehyde resin PE (2012)

Cross laminated Timber:

US: Laminated veneer lumber, at plant, US PNW USLCI/PE (2009)

US: Laminated veneer lumber, at plant, US SE USLCI/PE (2009)

Based on the identical designs and Tally® data input of Stadthaus at Murray Grove using cross laminated timber (CLT) and a laminated veneer bamboo (LVB) alternative, the results show that utilising a engineered bamboo diaphragm panel will result in a lower overall GWP. The LVB option out performs the CLT option by 33% or 207,975 kgCO_2eq. This lower GWP is based on the assumption that the LVB diaphragm panel system is structurally adequate to support the loading in a high rise construction. However, a range of values will be presented at the end of this should the diaphragm system not perform adequately.

Bamboo diaphragm system – 412,010 kgCO_2eq

Cross Laminated Timber – 619,985 kgCO_2eq

The Bamboo LVB diaphragm option out performs the cross laminated timber option in all three of the life cycle stages calculated as part of this study. See table 15 on the page over.

Life Cycle Categories	**Bamboo LVB Diaphragm Box (KgCO_2e)**	**Cross Laminated Timber (KgCO_2e)**
Manufacturing	193,412	287,985
Maintenance and Replacement	1,014	5,462
End of Life	217,582	326,538
Totals	**522,751**	**723,743**

Table 17: Comparison of Life Cycle Stages 12mm x 128mm depth

These three stages are:

1. The manufacturing stage; which includes the LCA data associated to all aspects of a **cradle to gate** LCA e.g. raw material acquisition, average transportation values of raw material to factory and all stages of the manufacture of the product/material.
2. The maintenance and replacement stage; which includes all environmental impact of constructing and maintaining the material over a 50 year period (the period of time defined within the Tally® application
3. The end of life stage; which in both instances:
   - 14.5% recovered (credited as avoided burden)
   - 22% incinerated with energy recovery
   - 63.5% landfilled (wood product waste) (Tally, 2015)

Advancing on these initial results and to further compare the selection of laminated veneer bamboo a series of further models and LCA tests were conducted on different configurations of panels. These models were created based on feedback regarding the structural capabilities of the LVB system from advisor John Lauder and ARUP engineers. These models were designed with the following materials and configurations:

1. 24mm thick **LVB** sheets used to create a typical panel size of 1220mmx2440mmx128mm with bridging supports at c.400mm.[15] This was tested against the Murray Grove CLT option also with 128mm depth panels
2. 24mm thick **plywood** sheets used to create a typical panel size of 1220mmx2440mmx128mm with bridging supports at c.400mm.[16] This was tested against a mass bamboo solid panel option of the Murray Grove also with 128mm depth panels

[15] Variations were modelled for windows and doors but followed a similar design with the area for windows and doors removed
[16] Variations were modelled for windows and doors but followed a similar design with the area for windows and doors removed

3. Finally a hybrid option of **Mass bamboo solid panels** with 128mm depth were placed on floors 1-5 and the **LVB diaphragm** panels place on the remaining 3 levels floor 6-9. This was tested against the Murray Grove **CLT** option also with 128mm depth panels. This model was constructed based on feedback from ARUP engineers on the most likely outcome based on the limited knowledge of the structural capacity of the panels.

The results of these tests showed that:

- The global warming potential of the 128mm plywood diaphragm panel with 24mm sheets was lower than a solid laminated veneer bamboo panel. This is due to the reduction of material used in this system. A margin of 23% or approximately 136,368 kgCO_2e is seen in the plywood diaphragm panel system against that of the solid laminated veneer bamboo panel system.
- The margin is marginally greater as seen in the LVB diaphragm option when compared to CLT. A margin of 25% or 153,374 kgCO_2eq for the 128mm depth laminated veneer bamboo diaphragm panel system with 24mm sheets **or** 33% or 207,975 kgCO_2eq difference for the 128mm depth laminated veneer bamboo diaphragm panel system with 12mm sheets v's cross laminated timber panel system. In this case LVB comes out more favourably when compared to CLT.
- The 128mm depth laminated veneer bamboo diaphragm panel system with 24mm sheets design option still marginally outperforms the Plywood diaphragm design option by 2% or 9,681 kgCO_2eq whereas the 128mm depth using the 12mm sheet outperforms the Plywood diaphragm design option by 13% or 64,282 kgCO_2eq
- A similar result can be seen in the cross laminated timber and solid laminated bamboo design options. The mass LVB design option outperforms the CLT design option marginally by 2% or 7,325 kg CO_2eq
- Finally the Mass bamboo and 128mm LVB diaphragm panel Hybrid building option (Mass LVB panels floor 1-5 & LVBD panel floor 6-9) outperforms a CLT option by 25% or 88,171 kg CO_2eq

Building Construction Type	Life Cycle Categories			
	End of Life	Maintenance and Replacement	Manufacturing	Totals
128mm Bamboo LVB Diaphragm Box **12mm Sheets**	217,582	1,015	19,341	412,010
128mm Bamboo LVB Diaphragm Box **24mm Sheets**	247,601	1,015	217,995	466,611
128mm Plywood Diaphragm Box **24mm Sheets**	271,758	1,015	203,520	476,292
Mass Bamboo and 128mm LVB diaphragm panel Hybrid option with **24mm Sheets**	283,445	1015	247,354	531,814
128mm Mass Solid Laminated Bamboo	298,338	5,462	308,860	612,660
128mm Cross Laminated Timber	326,538	5,462	287,985	619,985

Table 18: Global warming potential of 4 different building panel typologies for Stadthaus, Murray Grove, London

The results in table 16 above show that, when compared to CLT, under the environmental conditions outlined at the beginning of the chapter, a laminated veneer bamboo alternative superstructure has the potential to compete with and surpass an engineered wood based superstructure. Furthermore by implementing a more efficient use of materials which has been done in the LVB diaphragm design option GWP can be reduced by potentially 33% when compared to CLT.

Given the comparison of the options above highlighting that an LVB superstructure is marginally superior we can explore the implications of selecting a LVB option over a number of building projects in a year.

With the requirement for circa 20,000-30,000 new housing units required per year in Ireland this small margin, for even the worst case; 2% for Mass bamboo v CLT, would grow exponentially. In theory the more projects LVB is selected for the great the saving on GWP or $kgCO_2e$ produced and outputted into the environment. This coupled with a managed plantation system and crop rotation for bamboo as well as an increase in FSC certified bamboo plantations as discussed previously (section 1.4), means that a positive and more environmentally friendly approach to designing and building high rise residential buildings can be achieved.

A full breakdown of the life cycle impact of both the cross laminated timber and laminated veneer bamboo diaphragm design options can be found in the appendix.

8.0 Conclusion and comments

The aim of this research project was to establish, through a structural comparison review and comparative life cycle analysis (LCA), the overall contribution that laminated veneer bamboo (LVB) has to global warming potential against that of cross laminated timber (CLT). This study also set out to establish if engineered bamboo was a feasible alternative construction material to be used in high density urban housing. The following are the conclusions that can be drawn from the two major aspects of this research.

8.1 Structural Potential

It can be concluded from the structural assessment that engineered bamboo shows the potential to be implemented into mainstream construction typologies. The comparison of mechanical data supplied by Lamboo and SmartPly showed that LVB was a better performing material in all but one of the criteria. However, these values did come under some scrutiny and this shows that there is still a requirement to conduct full scale tests (as was intended as part of this research). Further research is needed to establish the mechanical properties of a panelised system. The panel system was designed and a lack of testing meant that some assumptions had to be made on its design and potential capabilities. Further research in this area should include:

- Manufacture panels (both solid and diaphragm panels) and conduct mechanical tests; compression, shear, tension and flexural on these full scale samples.
- Further research on how engineered bamboo should be implemented. Determine if a panelised system is the best application of engineered bamboo or if utilising bamboo in a post and beam system would be a better approach.
- Develop a set of building codes for use with engineered bamboo similar to those set up in *Eurocode 5: Design of Timber Structures.* By completing this it would ensure all standards and mechanical data is compiled for LVB structures and set up so as all buildings using this material are built safely and efficiently.

8.2 Environmental Assessment

This research reveals, through the environmental impact assessment of the case study model of Stadthaus at Murray Grove, London, and based on the criteria and system boundary set up for this study, engineered bamboo has a lower global warming potential in relation to cross laminated timber. The following are the conclusions on the environmental impact of a bamboo panelised system:

1. If bamboo is implemented efficiently into a diaphragm panel system (128mm depth) it can be up to 33% more efficient, in terms of $kgCO_2e$, than CLT.
2. If implemented into a solid panel system (128mm depth) it can be up to 2% more efficient, in terms of $kgCO_2e$, than CLT.
3. If implemented into a hybrid system of a solid panel system (128mm depth) and a diaphragm panel it can be up to 25% more efficient, in terms of $kgCO_2e$, than CLT.

It can be concluded that by implementing an engineered bamboo solution over a CLT solution on a similar building typology a reduction of between 2% and 33% can be achieved. Further research on the structural properties and capabilities of a panelised engineered bamboo building system may well reduce the percentage range presented. By first testing panel capabilities and then implementing the findings into the Revit model a more accurate set of data can be compiled.

Furthermore, the ability of bamboo to grow at a rapid rate of 3-5 years has major benefits on the environmental impact of harvesting it for construction purposes. With its ability to sequester larger amounts of CO_2 compared to timber, the results show that bamboo is a more favourable, environmentally friendly and sustainable material. With an increase in market share the values presented here will only continue to decrease in favour of bamboo. Additionally as previously suggested with the requirement for circa 20,000-30,000 new housing units required per annum in Ireland alone by implementing an LVB solution over a typical construction method the results could yield a major carbon footprint saving. The marginal difference between the LVB and CLT designs would grow exponentially for each project LVB is selected for A similar observation, although not in relation to environmental impact, is made by De Flander et al (2009) in their report previously discussed in the literature review that:

"If we compare this potential (of bamboo mainstream construction materials) *with the construction market of The Netherlands for example, with a current number of around 60,000 new-built houses per year and with an estimated market share of timber-frame dwellings of about 5% (and growing), we could say that laminated bamboo frame houses could easily replace these 3000 timber-frame houses and/or even better, take over part of the other non-bio-based mainstream construction materials such as concrete and bricks."* (De Flander & Rovers, 2009)

With a projected rise in population of 1.3 to 3.5 billion people by 2050, according to the UN, and the requirement to house the growing population a shift to more environmentally friendly, low GWP building materials needs to be considered in order to avoid further damage to the environment and a rise in global warming.

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Appendix

Contents

Literature review (Synopsis of reports and texts) Critical review

Research subject:

A Study of the Application of Engineered Bamboo, as a Sustainable Building Material, in Architectural Designs

Title of paper:

High Seas, High Stakes

Tyndall Center for Climate Change Research, University of Manchester

Abstract

This report serves to raise the profile of shipping decarbonisation by highlighting key research outputs from the EPSRC-funded High Seas Project. The report aims to:

- Illustrate implications of the quantitative framing of climate change for shipping
- Describe the shipping-specific policy and broader context
- Present a range of methodological approaches for quantifying shipping emissions
- Summarise opportunities and scenarios for rapid and significant decarbonisation in shipping
- Consider the policy implications of the High Seas Project research

During the High Seas Project, the research team have produced and disseminated a broad array of academic and policy-relevant outputs. This technical report summarises these outputs with links to detailed published work

Critical review

The shipping industry contributes to just below 3% of total global emissions, most of which comes from the burning of fossil fuels in cargo ships and heavy goods liners. This report aims to outline the problems associated to the shipping industry and how ‘ongoing climate negotiations aimed at preventing a rise of 2^{o}C above pre-industrial levels’. Yet the underlining factor is that fossil fuel emissions continue to grow across the shipping sector as well as others.

With that being said, shipping is still considered to be the most economical choice when it comes to the trade of goods in terms of tonne per kilometres. An increase of 4 per cent per annum on international trade since the 1990's has given rise to a reliance on fossil fuels. This in turn has led to a rise in CO_2 emissions of nearly the same percentage (3.7) per annum over the same period.

New regulations focused on marine fuel oil (MFO) are a step in the right direction for the shipping industry. MFO, with its high sulphur content, when burned releases sulphur oxides that damage the surrounding atmosphere. These regulations are essentially promoting a shift away from MFO but fail to address the overall opportunity to push more sustainable or renewable solutions to the problem.

A more 'Co-ordinated suite of measures' could be presented through legislation 'to address local and global pollution in unison'. As suggested by the authors 'radical step-change in forms of propulsion from the outset' are required to significantly reduce shipping emissions. Technologies such as wind and nuclear propulsion could greatly reduce carbon emissions in the sector.

Shipping Emissions

'It is widely accepted that shipping must reduce its CO_2 emissions, but the actual size of its global carbon wake is uncertain. Typically, it is estimated to account for about 3 per cent of global CO_2. If combined with CO_2 from aviation, this is similar to the total CO_2 produced by the African or Latin American continents, according to IEA statistics.

'The research within High Seas highlights that it is technically feasible to significantly decarbonise both new build ships and retrofits. However, many technologies that could be drawn upon are under-researched, not fully commercialised or considered to be too 'niche' to warrant consideration or investment at an appropriate scale.'

As part of the research for high seas the authors presented a case for a change in technologies and a range of measures to decarbonise vessels by 2050. This was done in a technology workshop and by using a tool, the ASK-C model, developed by the team for tracking CO_2 emissions for certain scenarios related to UK imports including technologies, operations and the demand for trade. The overall result of the workshop was a potential saving of >90% of CO_2 emissions from today's levels.

Some results of the study include

1. When considering alternative fuels, there needs to be a reliable supply to match demand, as well as infrastructure capable of production, distribution and storage.

2. The cumulative nature of CO2 emissions means that implementing mitigation measures in the short-term makes the challenge easier in the long-term.

3. Pursuing co-benefits of addressing CO2 and SOx emissions would likely reduce the impacts of infrastructure lock-in, as well as reducing potential lock-out of future low carbon fuels

'It is clear from the analysis that the greatest absolute reductions in shipping CO2 emissions are achieved when there is a reduction in both fuel and the distance travelled.' On the basis of this in relation to a study on bamboo, predominantly found in Asia or South America, a focus on fuel and alternative methods of propulsion to reduce CO_2 need to be considered for this study. However, a case for demand (tonne-km) and trade relations (goods travelling to and from/back and forth locations) could also have a dramatic effect on the overall output of CO_2 for this specific industry. By this I mean that the CO_2 per tonne km may be high but the amount of yearly trips is lower than other commodities in the same sector. This goes back to the point of demand and year on year emissions may change based on this. Categorically speaking the change needs to come from the fuel we use and the shift in a reliance on fossil fuels to more renewable resources. If this shift could be achieve emissions from the shipping sector could be reduced by +90% as predicted by testing in this body of research.

Technologies that can change in the shipping Industry

Nuclear

The application of nuclear power technology on land has its advantages and disadvantages. However, for use in the shipping industry, as a primary source of fuel, it has maintained the main focus for technology companies in the sector. Due to the rising cost of marine fuel, 'The development of small modular reactors for marine applications has been facilitated by the deployment of the technology on land, including the introduction of regulation and the addressing of safety concerns.'

Bio-fuels

Wind-propulsion technologies

Ship hull redesigns

Renewable energy retrofit technologies (Solar)

Key words/Key Sentences

Carbon Emissions
Transportation
Renewable
Shipping

Literature review (Synopsis of reports and texts) Critical review

Research subject:

A Study of the Application of Engineered Bamboo, as a Sustainable Building Material, in Architectural Designs

Title of paper:

Fire simulation test and analysis of laminated bamboo frame building

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c Zhejiang Prov. Institute of Architectural Design and Research, Hangzhou 310006, China

Abstract

A fire simulation experiment of a full-scale room unit model was carried out to study the fire safety of lightweight glue-laminated bamboo (glubam) frame buildings. Wooden crib with its quantity determined based on typical fire load intensity for residential buildings was stacked and ignited in the experimental room unit. The test was finished after 1 h. Temperature histories of several points on walls and upper floor slab, fire behaviour of the over-all structure and the damage to the members were examined. Numerical simulation was conducted using fire-driven fluid dynamics software Fire Dynamics Simulator (FDS) developed by National Institute of Standards and Technology (NIST). The simulated results were compared with the experimental observations, demonstrating that the FDS is a useful tool to provide visual simulation of the experimental testing. Fire design measures using gypsum boards and rock wool insulation suggested for the new bamboo building are found adequate from this research.

Critical review

In this study the author conducted a full scale fire simulation on a room unit constructed from Glubam wall panels. i.e 40mm x 84mm glue-laminated bamboo wall studs with 10mm plybamboo externally 10mm gypsum board internally and 84mm heat insulation material between studs. The schematic drawings can be seen in the report. Gypsum board used in this instance may have been a poor choice. If plybamboo was located on either side of the studs a more comprehensive study could have been undertaken on just the bamboo performance. However, as the author suggested, typical internal linings would usually incorporate gypsum board.

The experimental results present events occurring at different time frames throughout the fire simulation period, from ignition of the wooden crib, to the final extinguishment of the fire, as well as, a review of the structure 12 hours later.

- With interior temperature increasing, glasses on the door and window cracked at the 9th minute from ignition.
- In the following minutes, large deformations occurred to the plastic door and window frames.
- At about 16 min of burning, glasses all fell off, and the whole house started ventilating fully, allowing the wood combust more severely.
- Combustion occurred to most surface of wood crib (usually referred as flashover) at about 13th minute,
- wood crib fire reached its ultimate combustion state at the 18th minute after ignition. At about the 28th minute, the wood crib collapsed.
- At about the same time, cracks can be seen on the gypsum boards through burnt out window, however, the gypsum composite board was still intact.
- With continued burning, some damaged parts of the gypsum boards started to spall. It is deemed that gypsum composite board work better than ordinary gypsum board and fire-resist gypsum board according to the phenomenon during the test.
- After burning of about 40 min, the combustion started to slow down accompanied with wood burning out. The fire was extinguished by spraying water to the wood crib after 60 min since ignition.

It is reported that after 1 hour of exposure to fire the structural integrity of the room unit was retained although weaken slightly by the exposure to the fire. Mainly there was no complete burning through of the slab or walls. However as mentioned before the gypsum board had a major effect on the fire resistance performance of the internal faces of the room unit.

The average charring depth of bamboo studs was less than 25% of the sectional dimension due to the protection from gypsum boards installed on surface of walls.

A more thorough inspection after 12 h since the extinguishment of the fire revealed a smouldering zone near the upper portion of a section of wall. A small hole was formed in the wall and a small portion near the end of a beam was burnt for about a quarter of the beam depth due to the smouldering. These phenomena illustrate the good resistance of the Glubam elements once charring is formed.

A computer simulation was also conducted for validation purposes. See report for details.

How does it relate to the research subject?

This paper relates to the research due to a number of important references.

1. Demonstrates on a real life model the effect that heat and fire has on the structural integrity of a glue laminated bamboo building.
2. Adds to data already gained from “2. C.R. Assessment of fire reaction and fire resistance of guadua angustifolia kunth bamboo”

How it does not relate to the research subject?

- Unspecified species of bamboo used in Glubam however this could probably be found with some research into Glubam.

Key word/Key Sentences

Fire safety
Fire Performance
Glue laminated Bamboo
Bamboo Structure

“After 1 h fire effect, the Glubam structure house kept a good structural integrity, and there was no burning through on walls or slab. The structural soundness is key for allowing the resident to have sufficient time to escape the fire and for allowing firefighters arrive at the scene to put out the fire safely.”

“The average charring depth of bamboo studs was less than 25% of the sectional dimension due to the protection from gypsum boards installed on surface of walls.”

“According to temperature records, it was found that the highest temperature of interior wall or ceiling surface was recorded as 686^{o}C , while the highest temperature of exterior wall surface maintained between 46^{o}C and 84^{o}C, which is a lower temperature level below the ignition temperature of most materials.”

Literature review (Synopsis of reports and texts) Critical review

Research subject: A Study of the Application of Engineered Bamboo, as a Sustainable Building Material, in Architectural Designs

Title of paper

Compressive performance of laminated bamboo

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b Faculty of Science, Durham University, Durham DH1 3LE, England, United Kingdom

Abstract

This study investigated the compressive performance of 24 laminated bamboo specimens made from three different growth portions of the source bamboo. The cross-section of each specimen was 100 mm x 100 mm. The load–strain and load–displacement relationships are obtained from compression tests, and the detailed failure modes, compressive strength and elastic modulus for all specimens are reported. The results show that the mean compressive strength increases with growth portion height, but that the variation in compressive strength also increases with growth portion height. The net result is that the characteristic strength (typically used in the design process) decreases slightly with growth portion height, but not significantly. In contrast, laminated bamboo manufactured from the middle growth portion exhibits the highest elastic modulus, with the variation again increasing with height. Although the source growth portion has a clear effect on the behaviour of laminated bamboo under compression, the paper concludes that the effect is not significant from a design perspective. The results of all the tests are combined to produce a model stress–strain relationship suitable for predicting the performance of laminated bamboo under compression for design purposes. The stress–strain relationship shows that under compression laminated bamboo fails in a ductile manner. Based on the compressive properties obtained in this research, laminated bamboo is a suitable construction material for engineering structures.

Critical review:

As the abstract stated this study investigated the compressive performance of 24 laminated bamboo specimens made from three different growth portions; upper, middle and lower, of the source bamboo. The section of each specimen was 100 mm x 100 mm x 300mm. The load was applied initially through load control.

The specimens were tested using a micro-computer-controlled electro-hydraulic servo universal testing machine. *This Servo Universal Testing Machine is manufactured according to international standards and provides single test frame with dual zone to conduct Tensile, Compression and Flexural Test. Fully computerized models provides ease of use and* *customizable test result formats.* The load was initially applied through load control. The load was increase linearly to 200 KN at a rate of 0.7 kN/s, and then reduced linearly to 50 KN at the same rate. The load was then cycled linearly between 50 KN and 200 KN a total of six times in order to evaluate the elastic modulus accurately. The load was then increased linearly to 500 KN at the same loading rate, after which the testing process was changed to displacement control. The test continued at a displacement rate of 0.01 mm/s until the specimen had sustained significant damage, at which time testing was halted.

Analysis of results

Lower Growth Portion

In relation to the samples tested form the lower growth portion of the bamboo, the eight tests are remarkably consistent up until a displacement of approximately 16 mm. Each test shows a clear elastic behaviour up to a load of approximately 350 kN, followed by non-linear behaviour until approximately 550 kN, after which there is a plastic plateau. The six cycles of load between 50 and 200KN show little variation that the cycling is not visible on the graph (all the cycles plot over thr top of the main elastic loading line). The average compressive strength of this group of specimens is 57.9 MPa, with a very low standard deviation of 1.5 MPa. This compares with 54.2 MPa and a standard deviation of 2.9 MPa obtained for 30 x 30 mm specimens of lower growth height laminated bamboo by Yeh and Lin, and suggests that the lower strength in the lower growth portion of the bamboo culm is countered to some extent as the bamboo is laminated into larger structural members.

Middle Growth Portion

Like the first group, each test shows clear elastic behaviour up until a load of approximately 350 KN, followed by non-linear behaviour and a plastic plateau. However, unlike the specimens from the lower growth portion, there is significant variation in the plateau load, ranging from 550 KN to 670 KN The strongest two specimens do not exhibit a distinct plastic plateau, with the load increasing at a decreasing rate up to the maximum load and then decreasing at an increasing rate to a residual load. There is significantly more variation in the stress–strain between these specimens than was observed in the tests on the lower growth height specimens. However, the elastic behaviour is still quite consistent. As with the lower growth height specimens, the cycling between 50 and 200 KN resulted in no plotable changes in the strains between cycles. The average elastic modulus is 10,210 MPa with a standard deviation of 335 MPa, significantly higher than the average elastic modulus for the specimens sourced from the lower growth portion, and similar to the value of 10 GPa recommended by Wei et al. for the flexural elastic modulus. The average compressive strength of this group of specimens was 61.2 MPa with a standard deviation of 4.8 MPa. This compares with 66.1 MPa with a standard deviation of 1.9 MPa obtained Yeh and Lin in their study “Finger joint performance of a structural laminated bamboo member.” for similar bamboo from the middle growth portion, but tested in much smaller specimens (cross-section 30 x 30 mm).

Upper Growth Portion

This group of specimens shows the biggest variation in terms of ultimate stress, although again the elastic behaviour is still consistent and the cycling between 50 and 200 kN does not result in plotable changes in the strains between cycles. The average elastic modulus is 9322 MPa with a standard deviation of 362 MPa, somewhat lower than the average elastic modulus for the specimens sourced from the middle growth portion. Like the second group of specimens, one of the specimens from this group achieved strains similar to the average strain over the length of the specimen when unloading commenced (50,000+ l), suggesting that the material to which the strain gauges were attached was undergoing plastic deformation. In keeping with the lower and middle specimen groups, the other specimens exhibited lower strains than the corresponding displacement indicated, suggesting that plastic deformation was happening in other regions of the specimens. The average compressive strength of this group of specimens was 62.7 MPa with a standard deviation of 7.0 MPa. This compares with 69.6 MPa with a standard deviation of 2.7

MPa obtained Yeh and Lin for similar bamboo from the upper growth portion, but tested with a specimen of cross-section 30 _ 30 mm.

Effect of Growth portion of source bamboo

The graph to the right (Fig 1) shows the variation in ultimate stress amongst the test specimens plotted against the growth height group. Also plotted on the graph is the mean ultimate stress for each group and the characteristic strength of each group, calculated on the basis that 95% of samples will exceed the characteristic strength (mean ultimate stress – 1.645 x standard deviation). This figure shows clearly that although the mean strength increases slightly with the source growth height, the variation in the test results also increases. As a result, the characteristic strength decreases slightly with growth height, although this decrease is small compared with the variation in the test results.

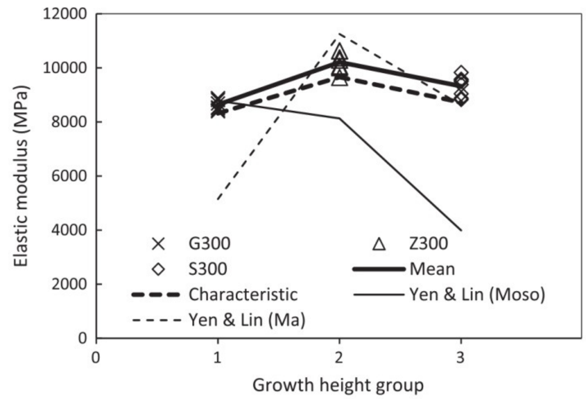


Fig 1. Effect of growth height on ultimate stress

Fig. 2 to the right plots the variation of elastic modulus with growth height. Unlike the strength results, the relationship is not monotonic, with the highest stiffness being measured for the specimens sourced from the middle growth height. The standard deviation of the results is again higher for the specimens from the middle and upper growth heights, but the variability of the results is smaller than the variability in compressive strength.

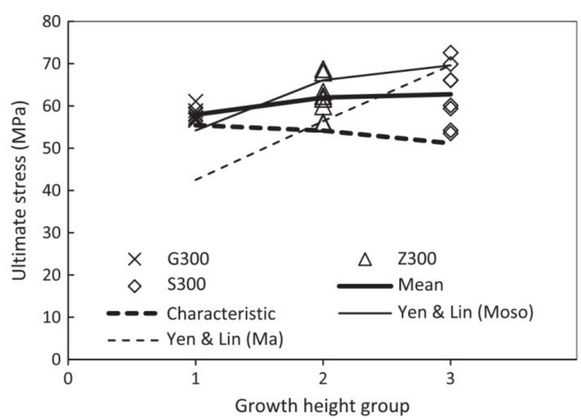


Fig 2. Effect of growth height on elastic modulus

Conclusions

As per the report

In order to investigate the compressive properties of structural laminated bamboo, 24 axial compression tests have been performed. The bamboo for the specimens was sourced from three different growth heights of the bamboo culm, with eight specimens sourced from each growth height. Each specimen was 100 x 100 mm in cross-section and 300 mm high. Based on the analysis of the test data, the following conclusions can be drawn.

1. The mean compressive strength of the samples from higher growth heights was higher, although not to the same extent as has been observed in tests on smaller samples, suggesting that assembling bamboo into larger structural sections reduces the influence of growth height of the original bamboo.
2. The variation of ultimate compressive strength increases with growth height. The results from this study show that the increase in variability more than counteracts the increase in mean compressive strength from a design point of view.
3. The elastic modulus is largest for the bamboo laminate sourced from the middle growth section. However, there is not a great deal of variation of elastic modulus with growth height.
4. From a design point of view, the variation in compressive strength resulting from source bamboo growth height can be neglected. A tri-linear model based on a characteristic elastic modulus of 8200 MPa up to a stress of 40 MPa, then a modulus of 800 MPa up to a stress of 52 MPa, followed by perfectly plastic deformation to an ultimate strain of 50,000 μ was found to provide an appropriate structural design model for the average behaviour of the structural laminated bamboo tested.
5. This stress–strain relationship shows that under compression laminated bamboo fails in a ductile manner and has quite consistent strength and stiffness. Based on these

compressive properties, laminated bamboo is a suitable construction material for engineering structures.

Studio Test Revision

Design Option Comparison

19/11/2014

Table of Contents

Report Summary

Created with Tally
Trial Version 2014.06.17.01

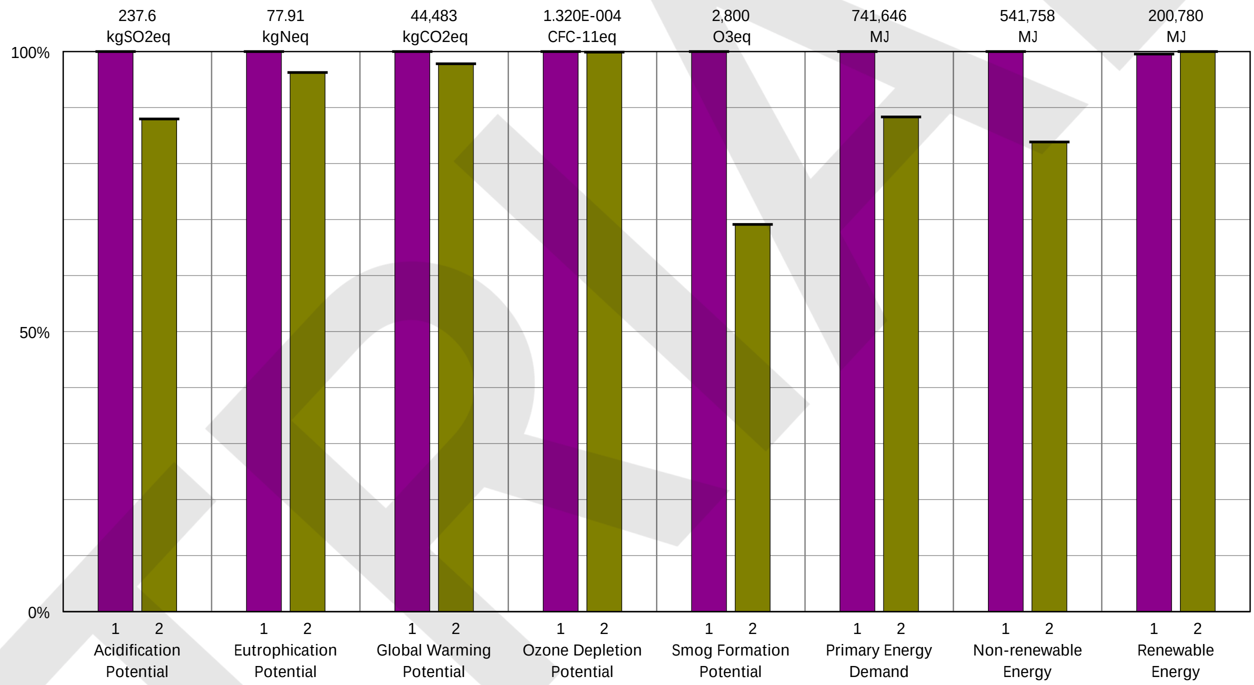
Author : Philip Kavanagh
Company : Dublin Institute of Technology
Date : 19/11/2014

Project : Studio Test Revision
Location : Dublin, Ireland
Gross Area : 70 m²
Building Life : 50

Scope : Cradle-to-Grave, exclusive of operational energy

Goal of Assessment :
Test Studio Revision

Object of Study
Design options set 'Wall Build up'
Bamboo
CLT (primary)



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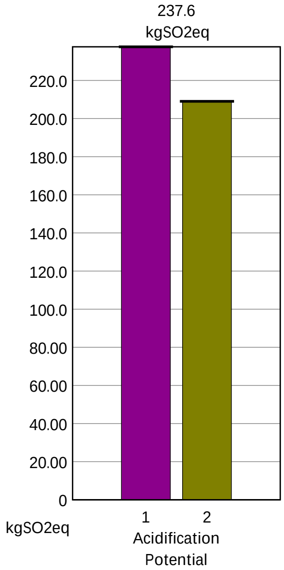
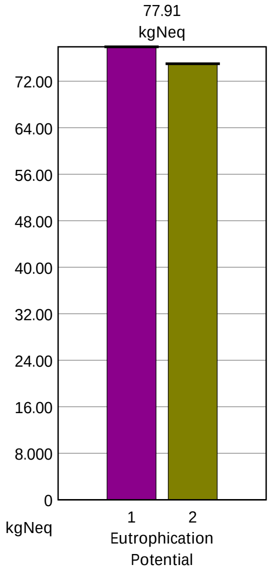
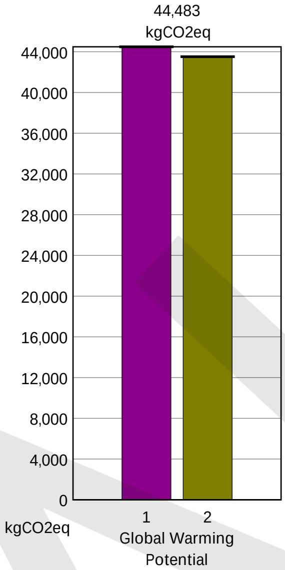
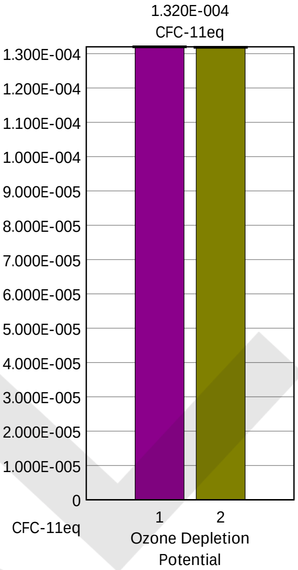
Design Options
Bamboo
CLT (primary)

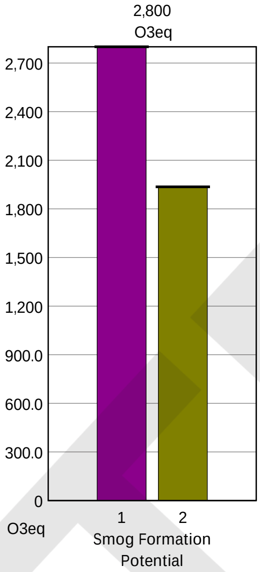
Report Summary (continued)

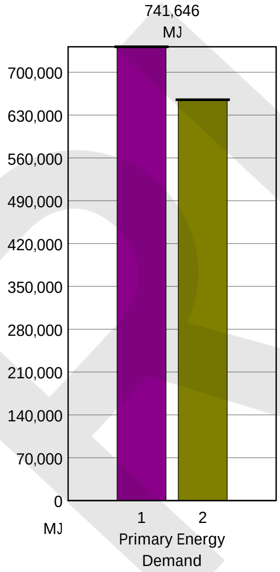


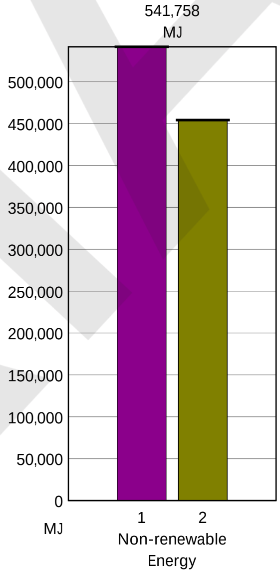


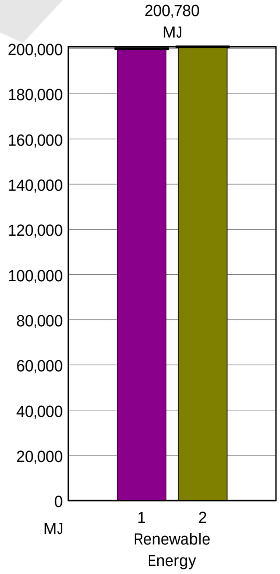












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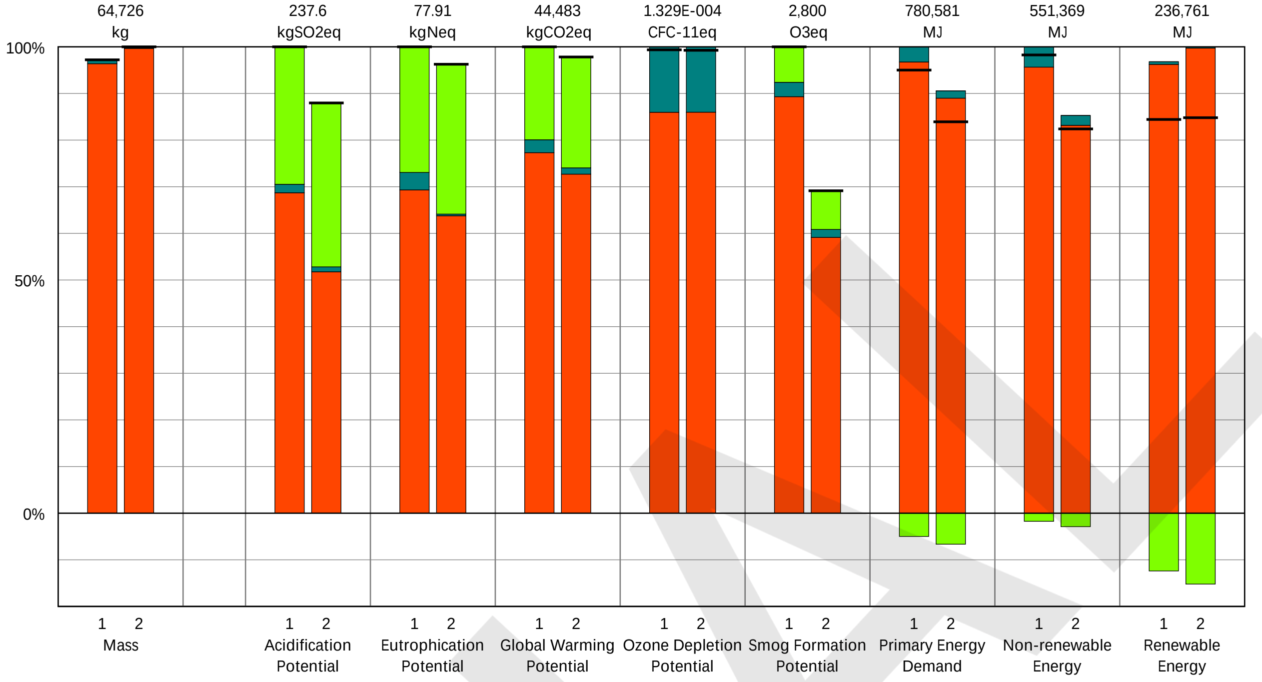
Design Options

- Bamboo
- CLT (primary)

Results per Life Cycle Stage



Legend

Net value (impacts + credits)

Design Options

Option 1 - Bamboo

Option 2 - CLT (primary)

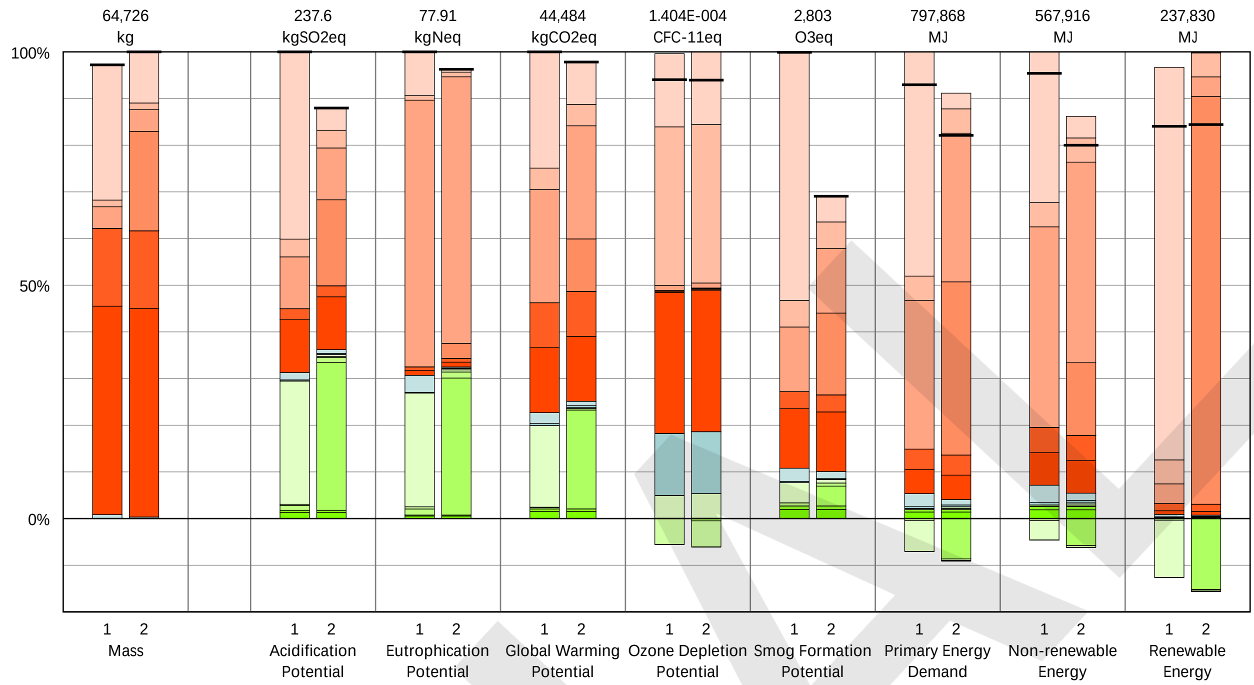
Life Cycle Stages

Manufacturing

Maintenance and Replacement

End of Life

Results per Life Cycle Stage, itemized by CSI Division



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Design Options

Option 1 - Bamboo
Option 2 - CLT (primary)

Manufacturing

- 03 - Concrete
- 04 - Masonry
- 05 - Metals
- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes

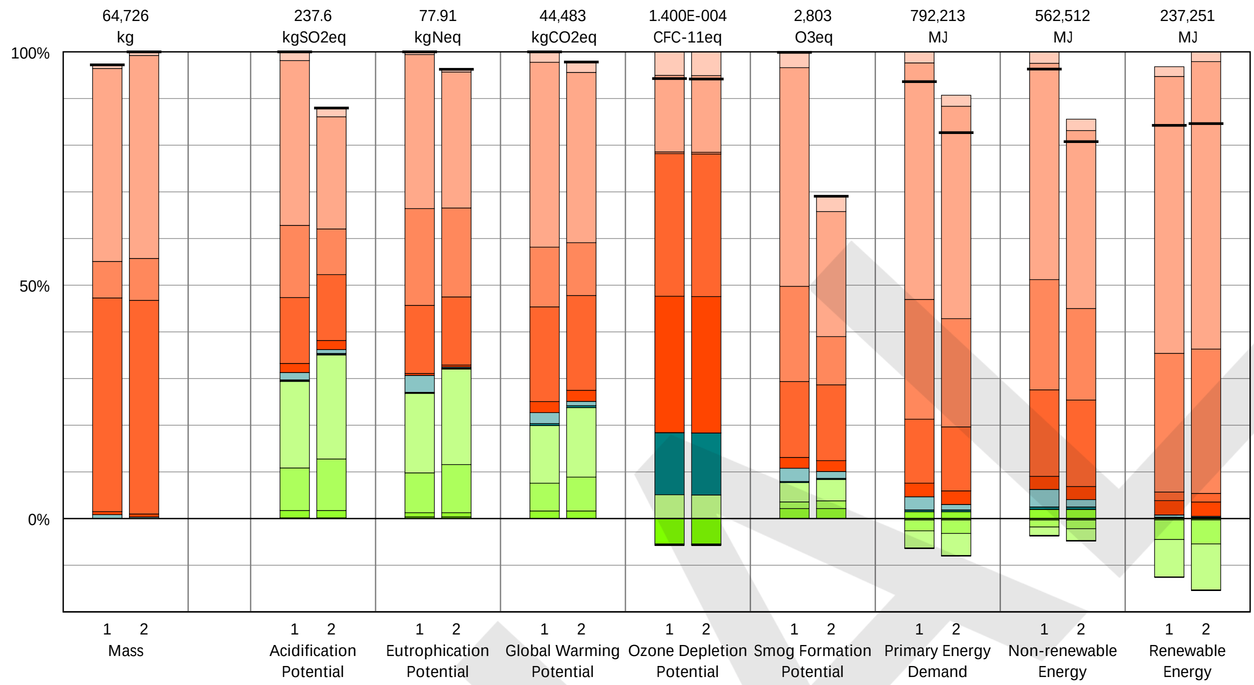
Maintenance and Replacement

- 03 - Concrete
- 04 - Masonry
- 05 - Metals
- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes

End of Life

- 03 - Concrete
- 04 - Masonry
- 05 - Metals
- 06 - Wood/Plastics/Composites
- 07 - Thermal and Moisture Protection
- 08 - Openings and Glazing
- 09 - Finishes

Results per Life Cycle Stage, itemized by Revit Category



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Net value (impacts + credits)

Design Options

Option 1 - Bamboo
Option 2 - CLT (primary)

Manufacturing

- Doors
- Floors
- Roofs
- Walls
- Windows

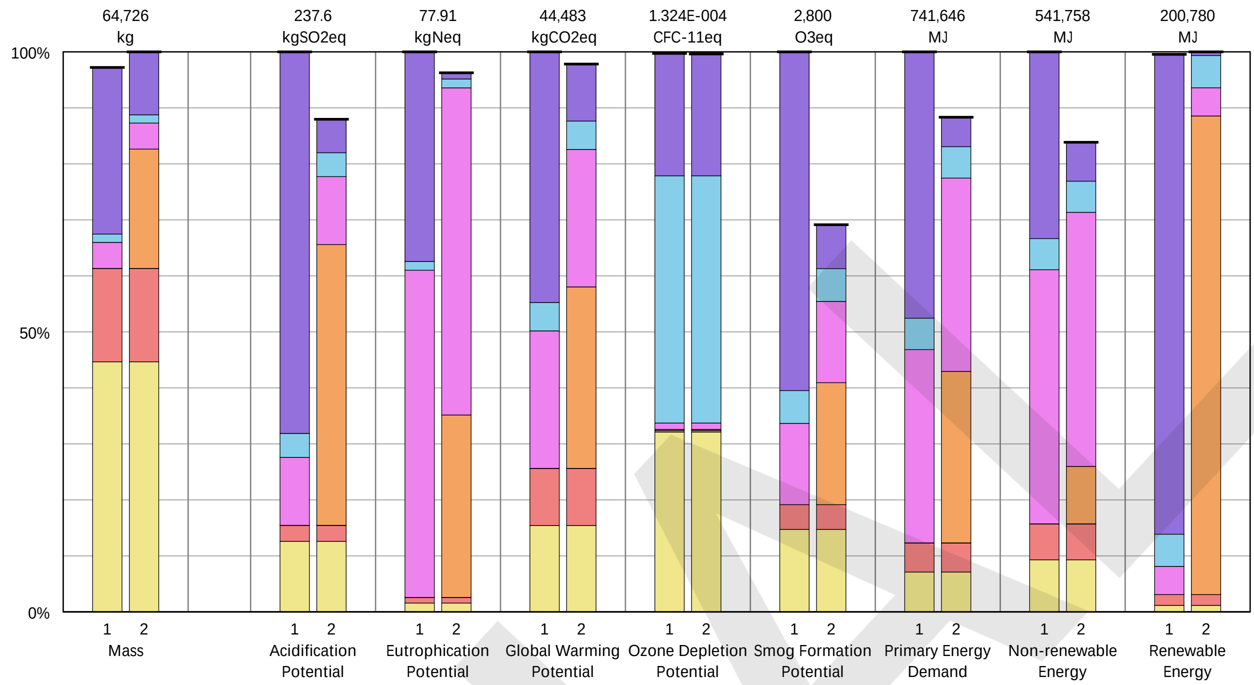
Maintenance and Replacement

- Doors
- Floors
- Roofs
- Walls
- Windows

End of Life

- Doors
- Floors
- Roofs
- Walls
- Windows

Results per CSI Division



Legend

Design Options

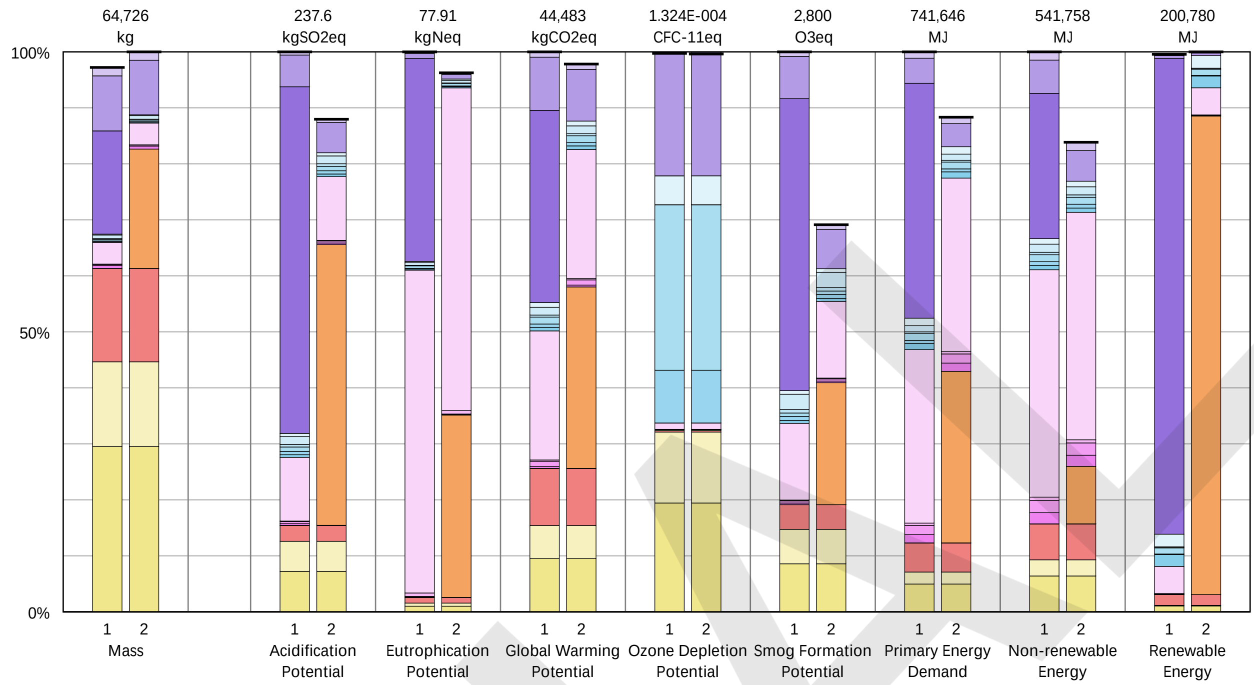
Option 1 - Bamboo

Option 2 - CLT (primary)

CSI Divisions

03 - Concrete
04 - Masonry
05 - Metals
06 - Wood/Plastics/Composites
07 - Thermal and Moisture Protection
08 - Openings and Glazing
09 - Finishes

Results per CSI Division, itemized by Tally Entry



Legend

Design Options

Option 1 - Bamboo

Option 2 - CLT (primary)

03 - Concrete

- Cast-in-place concrete, reinforced structural concrete, 10000 psi (70 MPa)
- Concrete, unreinforced, generic, 5000 psi (50MPa)

04 - Masonry

- Autoclaved aerated concrete block (AAC)

05 - Metals

- Stainless steel, hardware

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam / CLT)

07 - Thermal and Moisture Protection

- Asphalt felt sheet
- EPDM sheet, waterproofing
- Flashspun HDPE vapor retarder
- Polyisocyanurate (PIR), board

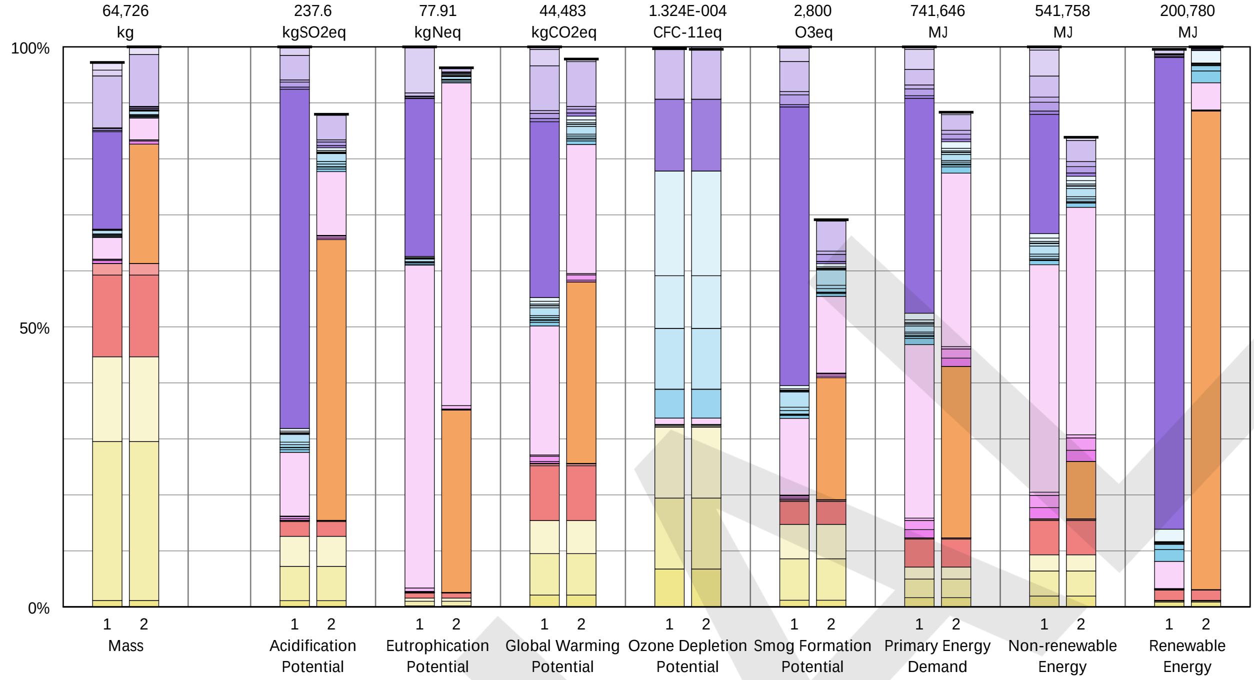
08 - Openings and Glazing

- Door frame, wood
- Door, exterior, glass
- Door, interior, wood, MDF core, flush
- Glazing, monolithic sheet
- Glazing, triple pane IGU
- Window frame, wood

09 - Finishes

- Flooring, bamboo plank
- Portland cement stucco, metal lath
- Wall board, gypsum

Results per CSI Division, itemized by Material



Legend

Design Options

Option 1 - Bamboo
Option 2 - CLT (primary)

03 - Concrete

- Steel, reinforcing rod
- Structural concrete, 10000 psi, 50% fly ash
- Structural concrete, 5000 psi, generic

04 - Masonry

- Autoclaved aerated concrete block (AAC),10x8x24
- Mortar type N
- None
- Steel, reinforcing rod

05 - Metals

- Hardware, stainless steel

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam)
- None

07 - Thermal and Moisture Protection

- Asphalt felt sheet, roofing underlayment
- EPDM
- Polyethelene sheet vapor barrier (HDPE)
- Polyisocyanurate (PIR), rigid foam insulation

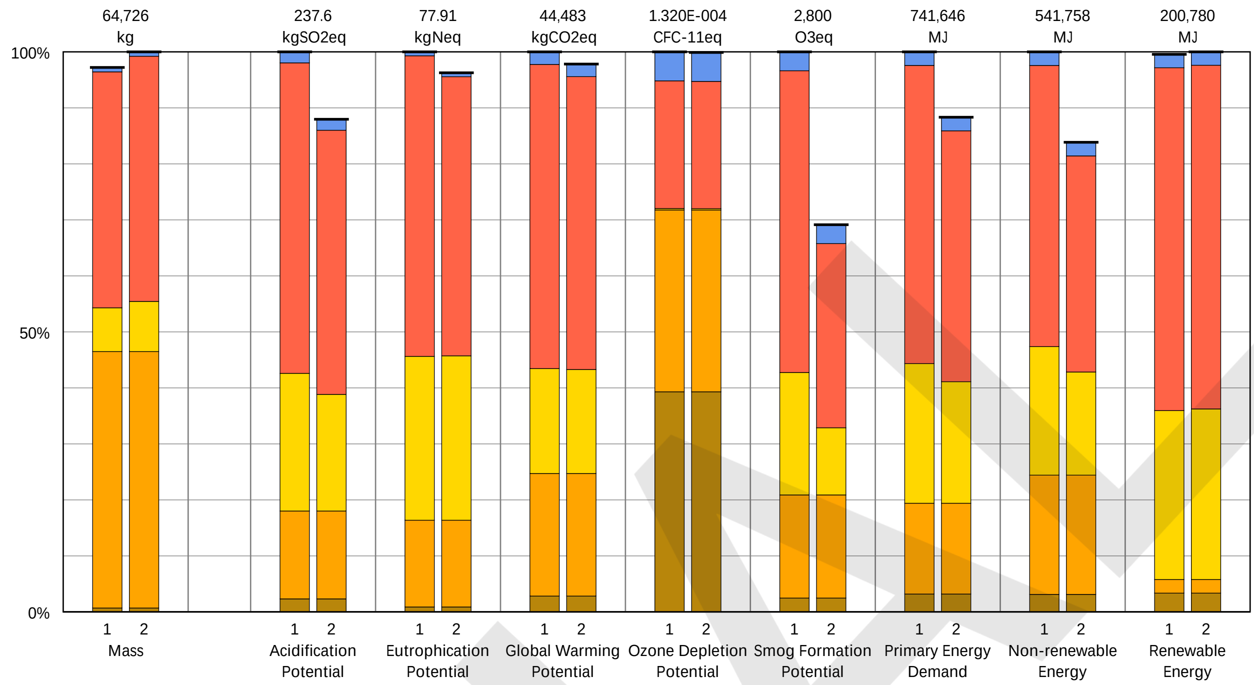
08 - Openings and Glazing

- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Galvanized steel tilt-turn window fittings for wood- and PVC-window, EPD - FSB
- Glazing, monolithic sheet, fritted
- Glazing, triple, 3 mm, laminated safety glass
- Glazing, triple, insulated (argon), low-E
- Integrated door closer, gray cast iron, EPD - FSB
- Paint, interior acrylic latex
- Stainless steel, door hardware, lever lock, exterior, commercial
- Stainless steel, door hardware, lever lock, interior, commercial
- Window frame, wood, operable

09 - Finishes

- Flooring, bamboo plank
- Metal lath, for plaster
- None
- Paint, exterior acrylic latex
- Paint, interior acrylic latex
- Stucco, portland cement
- Urethane adhesive
- Wall board, gypsum, fire-resistant (Type X)

Results per Revit Category



Legend

Design Options

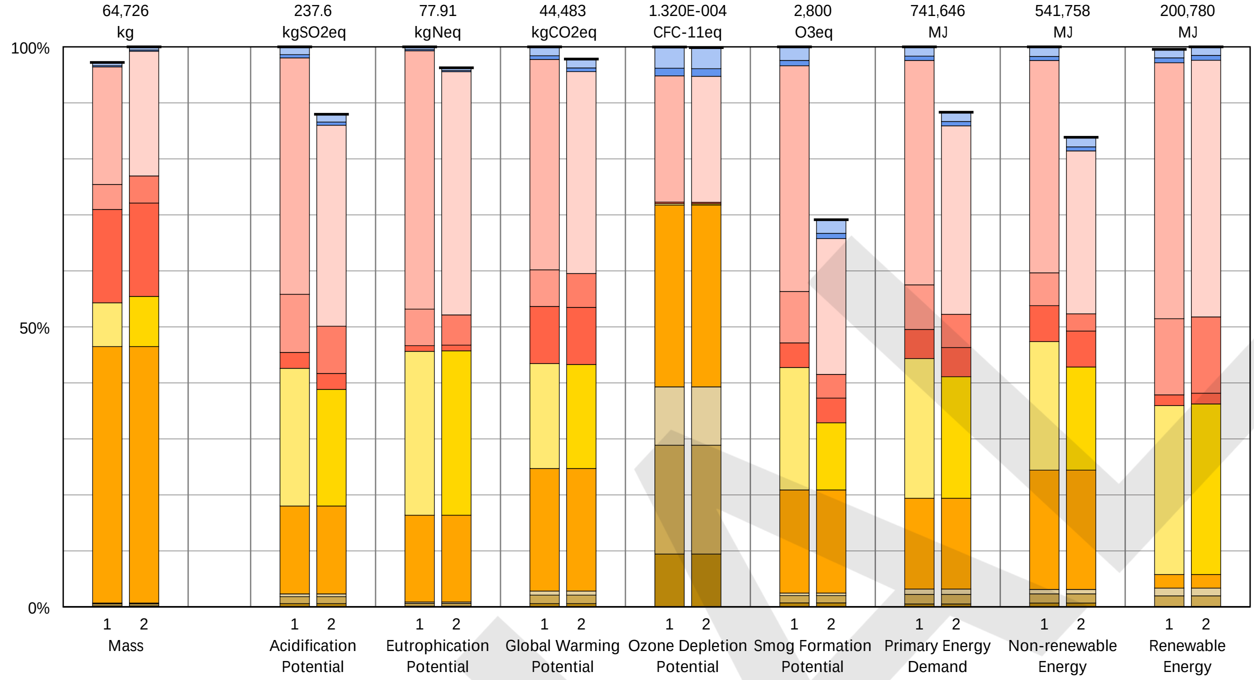
Option 1 - Bamboo

Option 2 - CLT (primary)

Revit Categories

- Doors
- Floors
- Roofs
- Walls
- Windows

Results per Revit Category, itemized by Family



Legend

Design Options

Option 1 - Bamboo
Option 2 - CLT (primary)

Doors

Doors_Concept_ExtDbl: 1810x2110mm
Doors_IntDbl_2: 1510x2110mm
IntSgl (7): 810 x 2110mm

Floors

Ground Bearing Conc - Ins Over

Roofs

A CLT w/ 120i
AA LVB w/ 120i

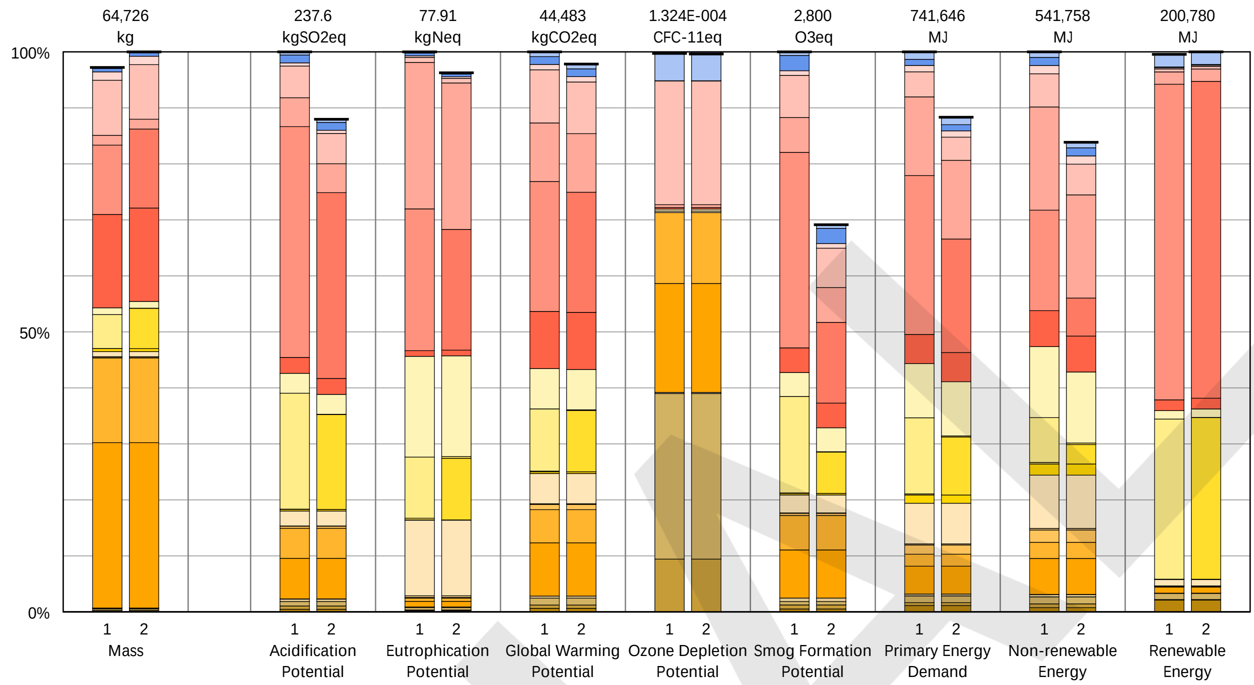
Walls

A Fnd 440 Trench Blockwk 2
A Partn - 100 clt - 1/2Hr
A Partn - 100 LVB 1/2Hr 2
A. Bamboo 5r 120i 120s 25 12p
A. CLT 5r 120i 120s 25 12p

Windows

Sgl Plain: 630 x 1050mm Deep
Tpl Plain: 1770 x 1050mm Deep

Results per Revit Category, itemized by Tally Entry



Legend

Design Options

Option 1 - Bamboo

Option 2 - CLT (primary)

Doors

- Door frame, wood
- Door, exterior, glass
- Door, interior, wood, MDF core, flush
- Glazing, monolithic sheet
- Stainless steel, hardware

Floors

- Cast-in-place concrete, reinforced structural concrete, 10000 psi (70 MPa)
- Concrete, unreinforced, generic, 5000 psi (50MPa)
- EPDM sheet, waterproofing
- Flashspun HDPE vapor retarder
- Polyisocyanurate (PIR), board

Roofs

- Asphalt felt sheet
- Cross laminated timber (CrossLam / CLT)
- Flashspun HDPE vapor retarder
- Flooring, bamboo plank
- Polyisocyanurate (PIR), board

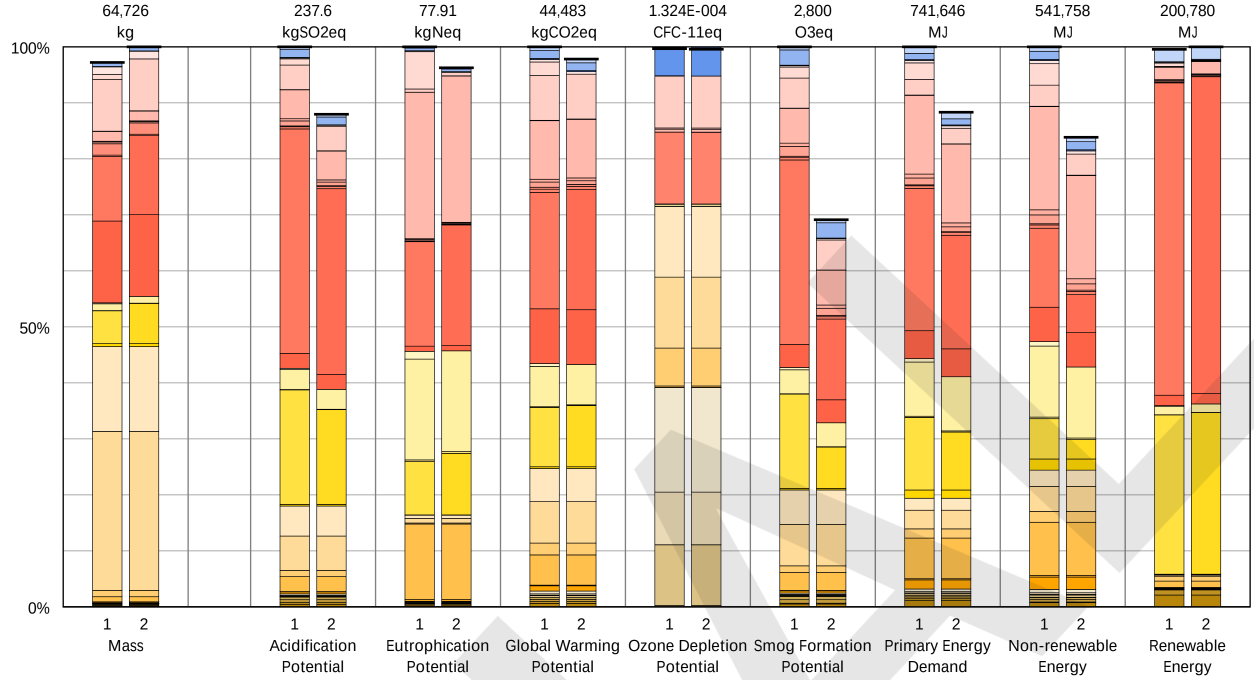
Walls

- Autoclaved aerated concrete block (AAC)
- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank
- Polyisocyanurate (PIR), board
- Portland cement stucco, metal lath
- Wall board, gypsum

Windows

- Glazing, triple pane IGU
- Window frame, wood

Results per Revit Category, itemized by Material



Legend

Design Options

Option 1 - Bamboo

Option 2 - CLT (primary)

Doors

- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Glazing, monolithic sheet, fritted
- Glazing, triple, 3 mm, laminated safety glass
- Hardware, stainless steel
- Integrated door closer, gray cast iron, EPD - FSB
- Paint, interior acrylic latex
- Stainless steel, door hardware, lever lock, exterior, commercial
- Stainless steel, door hardware, lever lock, interior, commercial

Floors

- EPDM
- Polyethelene sheet vapor barrier (HDPE)
- Polyisocyanurate (PIR), rigid foam insulation
- Steel, reinforcing rod
- Structural concrete, 10000 psi, 50% fly ash
- Structural concrete, 5000 psi, generic

Roofs

- Asphalt felt sheet, roofing underlayment
- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None
- Polyethelene sheet vapor barrier (HDPE)
- Polyisocyanurate (PIR), rigid foam insulation
- Urethane adhesive

Walls

- Autoclaved aerated concrete block (AAC),10x8x24
- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- Metal lath, for plaster
- Mortar type N
- None
- Paint, exterior acrylic latex
- Paint, interior acrylic latex
- Polyisocyanurate (PIR), rigid foam insulation
- Steel, reinforcing rod
- Stucco, portland cement
- Urethane adhesive
- Wall board, gypsum, fire-resistant (Type X)

Windows

- Galvanized steel tilt-turn window fittings for wood- and PVC-window, EPD - FSB
- Glazing, triple, insulated (argon), low-E
- Window frame, wood, operable

Calculation Methodology

Studied objects
The LCA results in the report represent either an analysis of a single building, or a comparative analysis of two or more building design options. The single building may represent the complete architectural, structural, and finish systems of a building or a subset of those systems, and it may be used to compare the relative contributions of building systems to environmental impacts and for comparative study with one or more reference buildings. The comparison of design options may represent a full building in various stages of the design process, or they may represent multiple schemes of a full or partial building that are being compared to one another across a range of evaluation criteria.

Functional unit and reference flow
The functional unit of the analysis is the usable floor space of the building under study. For a design option comparison of a partial building, the functional unit is the complete set of building systems that performs a given function. The reference flow is the amount of material required to produce a building, or portion thereof, designed according to the given goal and scope of the assessment, over the full life of the building. If operational energy is included in the assessment the reference flow also includes the electrical and thermal energy consumed on site over the life of the building. It is the responsibility of the modeler to assure that reference buildings or design options are functionally equivalent in terms of scope, size, and relevant performance. The expected life of the building has a default value of 60 years and can be modified by the model author.

System boundaries and delimitations
The analysis accounts for the full cradle-to-grave life cycle of the design options studied, including material manufacturing, maintenance and replacement, and eventual end-of-life (disposal, incineration, and/or recycling), including the materials and energy used across all life cycle stages. Optionally, the operational energy of the building can be included within the scope.

Architectural materials and assemblies include all materials required for the product's manufacturing and use (including hardware, sealants, adhesives, coatings, and finishing, etc.) up to a 1% cut-off factor by mass with the exception of known materials that have high environmental impacts at low levels. In these cases, a 1% cut-off was implemented by impact.

Manufacturing includes cradle-to-gate manufacturing wherever possible. This includes raw material extraction and processing, intermediate transportation, and final manufacturing and assembly. Due to data limitations, however, some manufacturing steps have been excluded, such as the material and energy requirements for assembling doors and windows. The manufacturing scope is listed for each entry, detailing any specific inclusions or exclusions that fall outside of the cradle-to-gate scope.

Transportation of upstream raw materials or intermediate products to final manufacturing is generally included in the GaBi datasets utilized within this tool. Transportation requirements between the manufacturer and installation of the product, and at the end-of-life of the product, are excluded from this study.

Infrastructure (buildings and machinery) required for the manufacturing and assembly of building materials, as well as packaging materials, are not included and are considered outside the scope of assessment.

Maintenance and replacement encompasses the replacement of materials in accordance with the expected service life. This includes the end-of-life treatment of the existing products and cradle-to-gate manufacturing of the replacement products. The service life is specified separately for each product.

Operational energy treatment is based on the anticipated energy consumed at the building site over the lifetime of the building. Each energy dataset includes relevant upstream impacts associated with extraction of energy resources (e.g., coal, crude oil), refining, combustion, transmission, losses, and other associated factors. US electricity generation datasets are based on subregions from US EPA's eGRID2012 database v1.0, but adapted to account for imports and exports into these regions. These consumption mixes - unique to the GaBi databases - provide a more accurate reflection of impacts associated with electricity consumption.

End-of-life treatment is based on average US construction and demolition waste treatment methods and rates. This includes the relevant material collection rates for recycling, processing requirements for recycled materials, incineration rates, and landfilling rates. Along with processing requirements, the recycling of materials is modeled using an avoided burden approach, where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material. Incineration of materials includes credit for average US energy recovery rates. The impacts associated with landfilling are based on average material properties, such as plastic waste, biodegradable waste, or inert material. Specific end-of-life scenarios are detailed for each entry.

Data source and quality
Tally utilizes a custom designed LCA database that combines material attributes, assembly details, and engineering and architectural specifications with environmental impact data resulting from the collaboration between KieranTimberlake and PE INTERNATIONAL. LCA modeling was conducted in GaBi 6 using GaBi databases and in accordance with GaBi database and modeling principles.

Geography and date: The data used are intended to represent the US and the year 2013. Where representative data were unavailable, proxy data were used. The datasets used, their geographic region, and year of reference are listed for each entry. An effort was made to choose proxy datasets that are technologically consistent with the relevant entry.

Uncertainty in results can stem from both the data used and the application of the data. Data quality is judged by its precision (measured, calculated, or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological). The LCI data sets from the GaBi LCI databases have been used in LCA models worldwide in industrial and scientific applications, both as internal and critically reviewed and published studies. The uncertainty introduced by the use of any proxy data is reduced by using technologically, geographically, and/or temporally similar data. It is the responsibility of the modeler to apply the predefined material entries appropriately to the building under study.

Tally methodology is consistent with LCA standards ISO 14040-14044.

Glossary of LCA Terminology

Environmental Impact Categories

The following list provides a description of environmental impact categories reported according to the TRACI 2.1 characterization scheme. References: [Bare 2010, EPA 2012, Guinée 2001]

Acidification Potential (AP) kg SO2 eq

A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline, and the deterioration of building materials.

Eutrophication Potential (EP) kg N eq

Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.

Global Warming Potential (GWP) kg CO2 eq

A measure of greenhouse gas emissions, such as CO2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health, and material welfare.

Ozone Depletion Potential (ODP) kg CFC-11 eq

A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants.

Smog Formation Potential (SFP) kg O3 eq

Ground level ozone is created by various chemical reactions, which occur between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in sunlight. Human health effects can result in a variety of respiratory issues including increasing symptoms of bronchitis, asthma, and emphysema. Permanent lung damage may result from prolonged exposure to ozone. Ecological impacts include damage to various ecosystems and crop damage. The primary sources of ozone precursors are motor vehicles, electric power utilities, and industrial facilities.

Primary Energy Demand (PED) MJ (lower heating value)

A measure of the total amount of primary energy extracted from the earth. PED is expressed in energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.) and energy demand from renewable resources (e.g. hydropower, wind energy, solar, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account.

LCA Metadata

NOTES

The following list provides a summary of all materials and energy inputs present in the selected study. Materials are listed in alphabetical order along with a list of all Revit families and Tally entries in which they occur and any notes and system boundaries accompanying their database entries. The mass given here refers to the full life-cycle mass of material, including manufacturing and replacement.

Asphalt felt sheet, roofing underlayment — 679.4 kg

Used in the following Revit families:

A CLT w/ 120i	339.7 kg
AA LVB w/ 120i	339.7 kg

Used in the following Tally entries:
Asphalt felt sheet

Description:
Asphalt felt sheet, exclusive of spray adhesive for roofing and wall application. Type I felt, also called No. 15 asphalt felt, is the minimum accepted by the IBC and IRC for underlayment and interlayment.

Life Cycle Inventory:
5 kg/m² bitumen sheet

Manufacturing Scope:
Cradle to gate

End of Life Scope:
5% recycled into bitumen (includes grinding energy and avoided burden credit)
95% landfilled (inert waste)

Entry Source:
DE: Bitumen sheet v 60 (EN15804 A1-A3) PE (2012)

Autoclaved aerated concrete block (AAC),10x8x24 — 18,888.6 kg

Used in the following Revit families:

A Fnd 440 Trench Blockwk 2	18,888.6 kg

Used in the following Tally entries:
Autoclaved aerated concrete block (AAC)

Description:
Autoclaved aerated concrete block (AAC), 10x8x24, excludes mortar

Life Cycle Inventory:
60-70% quartz sand
20-30% cement (type CEMI)
10-20% quick lime
2-5% gypsum

Manufacturing Scope:
Cradle to gate
excludes mortar
anchors, ties, and metal accessories outside of scope (<1% mass)

End of Life Scope:
50% recycled into coarse aggregate (includes grinding energy and avoided burden credit)
50% landfilled (inert material)

Entry Source:
EU-27: Aerated concrete block PE (2012)

Cross laminated timber (CrossLam) — 13,791.5 kg

Used in the following Revit families:

A CLT w/ 120i	4,660.6 kg
A Partn - 100 clt - 1/2Hr	2,164.8 kg
A. CLT 5r 120i 120s 25 12p	6,966.1 kg

Used in the following Tally entries:
Cross laminated timber (CrossLam / CLT)

Description:
PROXIED by LVL

Life Cycle Inventory:
43% PNW
57% SE
Proxied by LVL

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
US: Laminated veneer lumber, at plant, US PNW USLCI/PE (2009)
US: Laminated veneer lumber, at plant, US SE USLCI/PE (2009)

Door frame, wood, no door — 111.9 kg

Used in the following Revit families:

Doors_IntDbl_2: 1510x2110mm	59.6 kg
IntSgl (7): 810 x 2110mm	52.3 kg

Used in the following Tally entries:
Door frame, wood

Description:
Wood door frame

Life Cycle Inventory:
Dimensional lumber

Manufacturing Scope:
Cradle to gate, excludes hardware, jamnb, casing, sealant

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
DE: Wooden frame (EN15804 A1-A3) PE (2012)

Door, interior, wood, MDF Core, flush — 240.3 kg

Used in the following Revit families:

Doors_IntDbl_2: 1510x2110mm	156.4 kg
IntSgl (7): 810 x 2110mm	83.9 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Interior flush wood door with MDF core

Life Cycle Inventory:
12.2 kg/m² Wood, 0.052 m3/m3 MDF

Manufacturing Scope:
Cradle to gate, excludes assembly, frame, hardware, and adhesives

End of Life Scope:
14.5% wood products recovered (credited as avoided burden)
22% wood products incinerated with energy recovery
63.5% wood products landfilled (wood product waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)
DE: Wood fibre board PE (2012)

EPDM — 244.4 kg

Used in the following Revit families:

Ground Bearing Conc - Ins Over	244.4 kg

Used in the following Tally entries:
EPDM sheet, waterproofing

Description:
Roofing membrane (synthetic rubber sheet 45 mil)

Life Cycle Inventory:
EPDM sheet

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% to landfill (plastic waste)

LCA Metadata (continued)

Entry Source:
DE: EPDM roofing membranes (EN15804 A1-A3) PE (2012)

Flooring, bamboo plank 11,259.2 kg

Used in the following Revit families:

A Partn - 100 LVB 1/2Hr 2	1,768.1 kg
A. Bamboo 5r 120i 120s 25 12p	5,686.6 kg
AA LVB w/ 120i	3,804.6 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Bamboo plank flooring

Life Cycle Inventory:
90% Bamboo, 10% phenol formaldehyde

Manufacturing Scope:
Cradle to gate for raw material only, includes transportation from China and estimate for material processing neglects materials for installation

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
CN: Bamboo (estimation) PE (2012)
GLO: Bulk commodity carrier PE (2012)
US: Heavy fuel oil at refinery (0.3wt.% S) PE (2010)
CN: Electricity grid mix PE (2010)
DE: Phenol formaldehyde resin PE (2012)

Galvanized steel tilt-turn window fittings for wood- and PVC-window... 84.9 kg

Used in the following Revit families:

Sgl Plain: 630 x 1050mm Deep	22.3 kg
Tpl Plain: 1770 x 1050mm Deep	62.7 kg

Used in the following Tally entries:
Window frame, wood

Description:
Galvanized steel window fittings for wood and PVC windows

Life Cycle Inventory:
2.247 kg/piece
Galvanized steel

Manufacturing Scope:
Cradle to gate

End of Life Scope:
90% collection rate
remaining 10% deposited in the LCA model without recycling
material recycling efficiency dependant on the metal (89% steel, 90.2% aluminum, stainless steel 83%, zinc 91%, brass 94%)
Plastic components incinerated resulting in credits for electricity and thermal energy

Entry Source:
DE: Window fittings (tilt-turn wood- and PVC-window) - FV S+B PE-EPD (2009)
EOL - DE: Window fittings (tilt-turn wood and PVC) - FV S+B PE-EPD (2009)

Glazing, monolithic sheet, fritted 191.2 kg

Used in the following Revit families:

Doors_IntDbl_2: 1510x2110mm	191.2 kg

Used in the following Tally entries:
Glazing, monolithic sheet

Description:
1/2" float glass, fritted

Life Cycle Inventory:
3mm glazing
Frit mix: 90.9% glass granulate
9% butyl acetate
0.1% nitrocellulose
1 kg frit mix/m2 glass

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Window glass simple (EN15804 A1-A3) PE (2012)
US: Electricity grid mix PE (2010)
US: Thermal energy from natural gas PE (2010)
DE: Butyl acetate PE (2012)
DE: Nitrocellulose (cellulose nitrate) PE (2012)
DE: Expanded glass granulate PE (2012)
IT: Flat-screen printing ENEA (2002)
US: Tap water from groundwater PE (2012)

Glazing, triple, 3 mm, laminated safety glass 184.8 kg

Used in the following Revit families:

Doors_Concept_ExtDbl: 1810x2110mm	184.8 kg

Used in the following Tally entries:
Door, exterior, glass

Description:
Laminated glass, 3 lites 3 mm thick, inclusive of polyvinyl butyral, and sealant

Life Cycle Inventory:
0.80 kg/m² PVB film (30% adipic acid
70% PVB)
32.4 kg/m² glass

Manufacturing Scope:
Cradle to gate, excluding sealant

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Window glass simple (EN15804 A1-A3) PE (2012)
DE: Adipic acid from cyclohexane PE (2012)
DE: Polyvinyl Butyral Granulate (PVB) PE (2012)
GLO: Plastic film (PE, PP, PVC) PE (2012)
US: Electricity grid mix PE (2010)
US: Thermal energy from natural gas PE (2010)
US: Lubricants at refinery PE (2010)

Glazing, triple, insulated (argon), low-E 816.5 kg

Used in the following Revit families:

Sgl Plain: 630 x 1050mm Deep	214.3 kg
Tpl Plain: 1770 x 1050mm Deep	602.2 kg

Used in the following Tally entries:
Glazing, triple pane IGU

Description:
Glazing, triple, insulated (argon filled), 1/8" float glass, low-E, inclusive of argon gas fill, sealant, and spacers

Life Cycle Inventory:
32.4 kg/m² glass
Argon filled, 0.15 kg/m² low-e coating

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Insulation glass compound (3 panes) PE (2012)

Hardware, stainless steel 2.0 kg

Used in the following Revit families:

Doors_IntDbl_2: 1510x2110mm	1.3 kg
IntSgl (7): 810 x 2110mm	0.7 kg

Used in the following Tally entries:
Stainless steel, hardware

Description:

LCA Metadata (continued)

Finished, cast stainless steel entry applicable for door, window or other accessory hardware

Life Cycle Inventory:
Stainless steel

Manufacturing Scope:
Cradle to gate

End of Life Scope:
98% recovered (product has 58.1% scrap input while remainder is processed and credited as avoided burden)
2% landfilled (inert material)

Entry Source:
RER: Stainless steel Quarto plate (304) Eurofer (2008)
DE: Steel cast part machining PE (2012)
US: Electricity grid mix PE (2010)
RER: Stainless steel flat product (304) - value of scrap Eurofer (2008)

Integrated door closer, gray cast iron, EPD - FSB 40.0 kg

Used in the following Revit families:

Doors_IntDbl_2: 1510x2110mm	26.1 kg
IntSgl (7): 810 x 2110mm	14.0 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Integrated door closer - gray cast iron

Life Cycle Inventory:
2.045 kg/part
Cast iron

Manufacturing Scope:
Cradle to gate

End of Life Scope:
90% collection rate
remaining 10% deposited in the LCA model without recycling
material recycling efficiency dependant on the metal (89% steel, 90.2% aluminum, stainless steel 83%, zinc 91%, brass 94%)
Plastic components incinerated resulting in credits for electricity and thermal energy

Entry Source:
DE: Integrated door closer - gray cast iron - FV S+B PE-EPD (2009)
EOL - DE: Integrated door closer - gray cast iron - FV S+B PE-EPD

Metal lath, for plaster 331.7 kg

Used in the following Revit families:

A. Bamboo 5r 120i 120s 25 12p	165.9 kg
A. CLT 5r 120i 120s 25 12p	165.9 kg

Used in the following Tally entries:
Portland cement stucco, metal lath

Description:
Hot dip galvanized steel lath used as reinforcement of interior or exterior plaster (stucco).

Life Cycle Inventory:
Steel, hot dip galvanization

Manufacturing Scope:
Cradle to gate. Entry inclusive of galvanized metal sheet with some additional process energy.

End of Life Scope:
98% recovered (product has 10.3.% scrap input while remainder is processed and credited as avoided burden)
2% landfilled (inert material)

Entry Source:
GLO: Steel hot dip galvanized worldsteel (2007)
GLO: Steel sheet stamping and bending (5% loss) PE (2012)
US: Electricity grid mix PE (2010)
US: Lubricants at refinery PE (2010)
GLO: Compressed air 7 bar (medium power consumption) PE (2010)
GLO: Value of scrap worldsteel (2007)
GLO: Punching steel sheet small part PE (2011)

Mortar type N 2,634.4 kg

Used in the following Revit families:

A Fnd 440 Trench Blockwk 2	2,634.4 kg

Used in the following Tally entries:
Autoclaved aerated concrete block (AAC)

Description:
Mortar Type N (moderate strength mortar for use in masonry walls and flooring)

Life Cycle Inventory:
77% aggregate
12% cement
11% water

Manufacturing Scope:
Cradle to gate

End of Life Scope:
50% recycled into coarse aggregate (includes grinding energy and avoided burden credit)
50% landfilled (inert material)

Entry Source:
DE: Masonry mortar (MG II a) PE (2012)

None 0.0 kg

Used in the following Revit families:

A CLT w/ 120i	0.0 kg
A Fnd 440 Trench Blockwk 2	0.0 kg
A Partn - 100 clt - 1/2Hr	0.0 kg
A Partn - 100 LVB 1/2Hr 2	0.0 kg
A. Bamboo 5r 120i 120s 25 12p	0.0 kg
A. CLT 5r 120i 120s 25 12p	0.0 kg
AA LVB w/ 120i	0.0 kg

Used in the following Tally entries:
Autoclaved aerated concrete block (AAC)
Cross laminated timber (CrossLam / CLT)
Flooring, bamboo plank
Wall board, gypsum

Description:
This entry is a placeholder, for use in cases when there is "no" finish, or "no added material designated.

Manufacturing Scope:
NA

Entry Source:
None

Paint, exterior acrylic latex 347.1 kg

Used in the following Revit families:

A. Bamboo 5r 120i 120s 25 12p	202.4 kg
A. CLT 5r 120i 120s 25 12p	144.6 kg

Used in the following Tally entries:
Portland cement stucco, metal lath

Description:
Application paint emulsion (building, exterior, white). Assocaited look up table includes primer.

Life Cycle Inventory:
4.5% organic solvents

Manufacturing Scope:
Cradle to gate, including emissions during application

End of Life Scope:
100% to landfill (plastic waste)

Entry Source:
DE: Application paint emulsion (building, exterior, white) PE (2012)

LCA Metadata (continued)

Paint, interior acrylic latex — 191.7 kg

Used in the following Revit families:

A Partn - 100 clt - 1/2Hr	86.3 kg
A Partn - 100 LVB 1/2Hr 2	86.3 kg
Doors_IntDbl_2: 1510x2110mm	12.4 kg
IntSgl (7): 810 x 2110mm	6.7 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush
Wall board, gypsum

Description:
Application paint emulsion (building, interior, white, wear resistant)

Life Cycle Inventory:
2% organic solvents

Manufacturing Scope:
Cradle to gate, including emissions during application

End of Life Scope:
100% to landfill (plastic waste)

Entry Source:
DE: Application paint emulsion (building, interior, white, wear resistant) PE (2012)

Polyethelene sheet vapor barrier (HDPE) — 76.7 kg

Used in the following Revit families:

A CLT w/ 120i	19.2 kg
AA LVB w/ 120i	19.2 kg
Ground Bearing Conc - Ins Over	38.3 kg

Used in the following Tally entries:
Flashspun HDPE vapor retarder

Description:
Polyethelene sheet vapor barrier (HDPE) membrane (entry exclusive of adhesive or other co-products)

Life Cycle Inventory:
Polyethylene film

Manufacturing Scope:
Cradle to gate

End of Life Scope:
10.5% recycled into HDPE (includes processing and avoided burden credit)
89.5% landiflled (plastic waste)

Entry Source:
US: Polyethylene High Density Granulate (PE-HD) PE (2012)
GLO: Plastic Film (PE, PP, PVC) PE (2012)
US: Electricity grid mix PE (2010)
US: Thermal energy from natural gas PE (2010)
US: Lubricants at refinery PE (2010)

Polyisocyanurate (PIR), rigid foam insulation — 5,018.4 kg

Used in the following Revit families:

A CLT w/ 120i	783.5 kg
A. Bamboo 5r 120i 120s 25 12p	1,138.5 kg
A. CLT 5r 120i 120s 25 12p	1,138.5 kg
AA LVB w/ 120i	783.5 kg
Ground Bearing Conc - Ins Over	1,174.5 kg

Used in the following Tally entries:
Polyisocyanurate (PIR), board

Description:
PIR board

Life Cycle Inventory:
Polyisocyanurate foam consists of aromatic polyester polyol, butane, MDI, surfactants, catalysts and Tris (2-chloroisopropyl) phosphate (TCPP).

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% landfilled (plastic waste)

Entry Source:
EU-27: Polyisocyanurate (PIR high-density foam) PE (2012)

Stainless steel, door hardware, lever lock, exterior, commercial — 35.4 kg

Used in the following Revit families:

Doors_Concept_ExtDbl: 1810x2110mm	35.4 kg

Used in the following Tally entries:
Door, exterior, glass

Description:
Stainless steel door fitting (hinges and lockset) for use on commercial exterior door assemblies.

Life Cycle Inventory:
Door hinges 0.622 kg/part, Mortise lockset, lever grd1 3.08 kg/part

Manufacturing Scope:
Cradle to gate, including disposal of packaging.

End of Life Scope:
90% collection rate
remaining 10% deposited in the LCA model without recycling
material recycling efficiency dependant on the metal (89% steel, 90.2% aluminum, stainless steel 83%, zinc 91%, brass 94%)
Plastic components incinerated resulting in credits for electricity and thermal energy

Entry Source:
DE: Fitting stainless steel - FSB (2009)

Stainless steel, door hardware, lever lock, interior, commercial — 70.5 kg

Used in the following Revit families:

Doors_IntDbl_2: 1510x2110mm	45.9 kg
IntSgl (7): 810 x 2110mm	24.6 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Stainless steel door fitting (hinges and lockset) for use on commercial interior door assemblies.

Life Cycle Inventory:
Door hinges 0.622 kg/part, Battalion Lever Lockset, Light Duty, Privacy 2.04 kg/part

Manufacturing Scope:
Cradle to gate, including disposal of packaging.

End of Life Scope:
90% collection rate
remaining 10% deposited in the LCA model without recycling
material recycling efficiency dependant on the metal (89% steel, 90.2% aluminum, stainless steel 83%, zinc 91%, brass 94%)
Plastic components incinerated resulting in credits for electricity and thermal energy

Entry Source:
DE: Fitting stainless steel - FSB (2009)

Steel, reinforcing rod — 1,518.3 kg

Used in the following Revit families:

A Fnd 440 Trench Blockwk 2	48.3 kg
Ground Bearing Conc - Ins Over	1,470.0 kg

Used in the following Tally entries:
Autoclaved aerated concrete block (AAC)
Cast-in-place concrete, reinforced structural concrete, 10000 psi (70 MPa)

Description:
Steel rod suitable for structural reinforcement (rebar), common unfinished tempered steel

Life Cycle Inventory:
Steel rebar

Manufacturing Scope:
Cradle to gate

End of Life Scope:
70% recovered (product has 69.8% scrap input while remainder is processed and credited as avoided burden)
30% landfilled (inert material)

LCA Metadata (continued)

Entry Source:
GLO: Steel rebar worldsteel (2007)

Structural concrete, 10000 psi, 50% fly ash 36,749.6 kg

Used in the following Revit families:
Ground Bearing Conc - Ins Over 36,749.6 kg

Used in the following Tally entries:
Cast-in-place concrete, reinforced structural concrete, 10000 psi (70 MPa)

Description:
Structural concrete, 10000 psi, 50% fly ash

Life Cycle Inventory:
8% cement
8% fly ash
46% gravel
31% sand
7% water

Manufacturing Scope:
Cradle to gate
excludes mixing and pouring impacts

End of Life Scope:
50% recycled into coarse aggregate (includes grinding energy and avoided burden credit)
50% landfilled (inert material)

Entry Source:
US: Portland cement, at plant USLCI/PE (2009)
US: Tap water from groundwater PE (2012)
EU-27: Gravel 2/32 PE (2012)
DE: Fly ash (EN15804 A1-A3) PE (2012)
US: Silica sand (Excavation and processing) PE (2012)

Structural concrete, 5000 psi, generic 19,595.2 kg

Used in the following Revit families:
Ground Bearing Conc - Ins Over 19,595.2 kg

Used in the following Tally entries:
Concrete, unreinforced, generic, 5000 psi (50MPa)

Description:
Structural concrete, generic, 5000 psi

Life Cycle Inventory:
15% cement
46% gravel
31% sand
7% water

Manufacturing Scope:
Cradle to gate
excludes mixing and pouring impacts

End of Life Scope:
50% recycled into coarse aggregate (includes grinding energy and avoided burden credit)
50% landfilled (inert material)

Entry Source:
US: Portland cement, at plant USLCI/PE (2009)
US: Tap water from groundwater PE (2012)
EU-27: Gravel 2/32 PE (2012)
US: Silica sand (Excavation and processing) PE (2012)

Stucco, portland cement 11,989.3 kg

Used in the following Revit families:
A. Bamboo 5r 120i 120s 25 12p 5,994.6 kg
A. CLT 5r 120i 120s 25 12p 5,994.6 kg

Used in the following Tally entries:
Portland cement stucco, metal lath

Description:
Portland cement plastering (stucco, 7/8" nominal thickness)

Life Cycle Inventory:
Light plaster

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
US: Silica sand (Excavation and processing) PE (2012)
US: Portland cement, at plant USLCI/PE (2009)
US: Lime (CaO) calcination PE (2012)

Urethane adhesive 672.1 kg

Used in the following Revit families:
A Partn - 100 LVB 1/2Hr 2 151.1 kg
A. Bamboo 5r 120i 120s 25 12p 404.9 kg
AA LVB w/ 120i 116.1 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Urethane adhesive for use with flooring and wall coverings.

Life Cycle Inventory:
50% limestone, 13% lime, 30% polyurethane, 1.5% stearic acid, 5% Methylene bis(phenylisocyanate) (MDI)
1.3% NMVOC emissions

Manufacturing Scope:
Cradle to gate, plus emissions during application

End of Life Scope:
98.7% solids to landfill (plastic waste)

Entry Source:
US: Limestone flour (5mm) PE (2012)
DE: Polyurethane (copolymer-component) (estimation from TPU adhesive) PE (2012)
US: Lime (CaO) calcination PE (2012)
US: Methylene diisocyanate (MDI) PE (2012)
DE: Stearic acid PE (2012)
US: Electricity grid mix PE (2010)

Wall board, gypsum, fire-resistant (Type X) 1,767.6 kg

Used in the following Revit families:
A Partn - 100 clt - 1/2Hr 883.6 kg
A Partn - 100 LVB 1/2Hr 2 884.0 kg

Used in the following Tally entries:
Wall board, gypsum

Description:
Fire-resistant gypsum board

Life Cycle Inventory:
1 kg gypsum wallboard

Manufacturing Scope:
Cradle to gate

End of Life Scope:
54% recycled into gypsum stone (includes grinding and avoided burden credit)
46% landfilled (inert waste)

Entry Source:
DE: Gypsum plaster board (Fire protection) (EN15804 A1-A3)PE (2012)

Window frame, wood, operable 117.0 kg

Used in the following Revit families:
Sgl Plain: 630 x 1050mm Deep 43.7 kg
Tpl Plain: 1770 x 1050mm Deep 73.3 kg

Used in the following Tally entries:
Window frame, wood

Description:
Operable wood casement window frame inclusive of paint

Life Cycle Inventory:
1.30 kg/m

LCA Metadata (continued)

Manufacturing Scope:
Cradle to gate
excludes hardware, casing, sealant beyond paint

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
DE: Wooden frame (EN15804 A1-A3) PE (2012)

has to comply with C1.10a. When particleboard or plywood is used as the substrate, the Early Fire Hazard Properties are those required in Specification C1.10 (Spread-of-Flame Index and Smoke-Developed Index). A CRF (and Smoke Development Rate if the building is unsprinklered) will be required for the floor covering. However, as the floor covering is part of an assembly (substrate and covering) a floor covering manufacturer should test the floor covering and substrate together to obtain a CRF value with the substrate underlay (e.g. plywood or particleboard) included. Often this is not done and therefore it is recommended that this be checked.

The Critical Radiant Flux and Smoke Development Rates for various timber species used for solid timber flooring is contained in the table below which is broken into two parts - 12 mm and greater and 19 mm and greater thickness for various solid timber species. For 12 mm solid timber flooring there is a requirement that it be backed by the appropriate plywood or particleboard, or placed onto a non-combustible substrate such as concrete.

Dusk project by architect Campbell Drake (Diretribe Pty Ltd) Winner of the Australian Timber Design Award 2007, Highly commended 2007 for both New Buildings or Renovation – Students & Entrants Under 30 and Best Use of Plywood & LVL. *Photography:* Tanja Kimme

Floating Floors

Recently, floating floors have been gaining in popularity particularly where a high level of amenity (for acoustic requirements for example) is needed. Floating floors can be made of a single timber species or combination of plywood, solid timber, timber veneer, bamboo, composite wood or a manufactured laminate. These are usually pre-finished and laid on a single or multiple underlay of foam, rubber or polyester sound reducing material. The flooring and underlay can have multiple shapes and properties, therefore it is recommended to refer to the manufacturer for the fire hazard properties in those instances.

Test Results for Solid Timber Flooring

Table 2 contains results for common solid timber. Where timber species are not listed refer to distributor of the product for further assistance.

Table 2: CRITICAL RADIANT FLUX (CRF) AND SMOKE DEVELOPMENT RATES OF SELECT SOLID TIMBER SPECIES**

	FIRE HAZARD PROPERTIES			
THICKNESS	**12 mm and greater**		**19 mm and greater**	
NAME	**Critical Radiant Flux [kW/m²]**	**Smoke Development Rate [percent-minutes]**	**Critical Radiant Flux [kW/m²]**	**Smoke Development Rate [percent-minutes]**
Ash, alpine	>2.2 and < 4.5	<750	>2.2 and < 4.5	<750
Ash, mountain	>2.2 and < 4.5	<750	>2.2 and < 4.5	<750
Ash, silvertop	>2.2 and < 4.5*	<750	>2.2 and < 4.5	<750
Beech, myrtle	>2.2 and < 4.5*	<750	≥ 4.5	<750
Blackbutt	>2.2 and < 4.5*	<750	>2.2 and < 4.5	<750
Blackbutt, New England	>2.2 and < 4.5*	<750	≥ 4.5	<750
Blackwood	>2.2 and < 4.5*	<750	≥ 4.5	<750
Bloodwood, red	>2.2 and < 4.5*	<750	≥ 4.5	<750
Box, brush	>2.2 and < 4.5*	<750	≥ 4.5	<750

	FIRE HAZARD PROPERTIES			
THICKNESS	12 mm and greater		19 mm and greater	
NAME	Critical Radiant Flux [kW/m²]	Smoke Development Rate [percent-minutes]	Critical Radiant Flux [kW/m²]	Smoke Development Rate [percent-minutes]
Cypress	>2.2 and < 4.5*	<750	≥ 4.5	<750
Gum, blue, Sydney	>2.2 and < 4.5	<750	>2.2 and < 4.5	<750
Gum, blue, southern	>2.2 and < 4.5*	<750	≥ 4.5	<750
Gum, manna	>2.2 and < 4.5*	<750	>2.2 and < 4.5	<750
Gum, red, river	>2.2 and < 4.5*	<750	≥ 4.5	<750
Gum, rose	>2.2 and < 4.5	<750	>2.2 and < 4.5	<750
Gum, shining	>2.2 and < 4.5	<750	>2.2 and < 4.5	<750
Gum, spotted	>2.2 and < 4.5*	<750	≥ 4.5	<750
Gum, sugar	>2.2 and < 4.5*	<750	≥ 4.5	<750
Gum, yellow	>2.2 and < 4.5*	<750	≥ 4.5	<750
Ironbark, grey	>2.2 and < 4.5*	<750	≥ 4.5	<750
Ironbark, red	>2.2 and < 4.5*	<750	≥ 4.5	<750
Jarrah	>2.2 and < 4.5*	<750	≥ 4.5	<750
Karri	>2.2 and < 4.5*	<750	≥ 4.5	<750
Mahogany, red	>2.2 and < 4.5*	<750	≥ 4.5	<750
Merbau	>2.2 and < 4.5*	<750	≥ 4.5	<750
Messmate	>2.2 and < 4.5*	<750	>2.2 and < 4.5	<750
Pine, celery-top	>2.2 and < 4.5	<750	>2.2 and < 4.5	<750
Pine, radiata	>2.2 and < 4.5*	<750	>2.2 and < 4.5	<750
Stringybark, yellow	>2.2 and < 4.5	<750	>2.2 and < 4.5	<750
Tallowwood	>2.2 and < 4.5*	<750	≥ 4.5	<750
Turpentine	>2.2 and < 4.5*	<750	≥ 4.5	<750
Wattle, silver	>2.2 and < 4.5*	<750	≥ 4.5	<750

* Tested with substrate

** Warrington Fire Research Australia Report RIR 41117.2

* TESTED SUBSTRATES FOR 12mm THICK TIMBER FLOORING

SUBSTRATE SPECIFICATION	THICKNESS [mm]
Particleboard (density 716 kg/m3)	**≥ 19 mm**
Fibre cement	**≥ 15 mm**
Normal weight concrete floor	**≥ 75 mm**
Light weight concrete floor	**≥ 75 mm**

Table 3 CRITICAL RADIANT FLUX (CRF) AND SMOKE DEVELOPMENT RATES OF SELECT PLYWOOD FLOORING

	FIRE HAZARD PROPERTIES		REPORT NUMBER
NAME	Critical Radiant Flux [kW/m²]	Smoke Development Rate [percent-minutes]	
Pine, hoop ≥ 15 mm	>2.2 and < 4.5	<750	RIR 41117.2*
Pine, radiata ≥ 17 mm	>2.2 and < 4.5	<750	RIR 41117.2*
Pine, slash ≥ 17 mm	>2.2 and < 4.5	<750	RIR 41117.2*

*Warrington Fire Research Australia

Outline of contact and correspondence with Cambridge University

Through initial research, literature studies as well as lead from contacts it was presented that there was research into engineered bamboo underway at Cambridge University the scope of the project is outlined below. A series of emails were sent to liaise and build up a relationship to promote and share information on the related topic. The following is a summary of the communication that took place.

The Scope of the Cambridge Study is as follows. Link to website where the scope is presented:

http://www.arct.cam.ac.uk/research/researchgroups/natural-materials-and-structures/structural-bamboo-products-sbp

Structural Bamboo Products

This project sets out to develop a code of practice for structural design and building construction with Structural Bamboo Products (SBP). Lead researcher: Michael Ramage

Bamboo has been used in construction since ancient times. It has many advantages as a construction material: It is a renewable, sustainable resource, with mechanical properties similar to those of wood, but with a 5 times higher growth rate than wood. The FAO's 2010 Forest Resource Assessment indicates that there are over 31.4 million hectares of bamboo worldwide.

The widespread usage of SBP is hampered by a lack of data for mechanical and thermal properties, for their manufacture, and a lack of appropriate building codes. Our goal is to develop a code of practice for structural design and building construction with SBP by

- creating material models of natural and engineered bamboo,

- creating products and manufacturing capability for SBP,

- performing structural experiments,

- adapting existing building codes for timber in earthquake areas to bamboo, and by developing an understanding of the environmental characteristics of bamboo materials and their production.

The project is a new collaboration with MIT, UBC and Cambridge Architectural Research. This research will contribute to the knowledge base and use of engineered bamboo. A major focus of the project is to enhance sustainability of building products through the development of a lower-carbon alternative to conventional structural components. Furthermore, well-designed buildings incorporating SBP will have lower operating energy use, and thus emit lower levels of carbon throughout their life cycles. The SBP and codes we develop will be a viable alternative to steel and concrete members, with a global outlook for sustainability.

Correspondence with Cambridge

>

Dear Mr. Ramage

My name is Philip Kavanagh. I am currently a MPhil student in Dublin School of Architecture, Dublin Institute of Technology, Ireland.

For my research I am looking into the application of engineered bamboo in architectural designs as a sustainable building material (for western cultures, Europe). Previously, I have looked into a comparative study of the life cycle of structural engineered bamboo products as sustainable building material v softwood engineered products. This was completed May 2013 as part of my final year under graduate thesis for my degree in Architectural Technology. The promising conclusions of that research have led me to continue the study further to master's level.

The focus of the new research is to further assess the environmental aspects of the selection of engineered bamboo for purposes in designs mainly in a European market. The main topics under consideration thus far are energy use, embodied energy, carbon emissions, transportation, local growth and global warming potential (LCA). For the last few weeks I have also been assessing the structural capabilities of the material further through a literature review to better familiarise myself with the properties. Through the research and contacts I have made, throughout my study, I was put on to the bamboo study on-going in Cambridge for which you are principle investigator.

If it was possible I would like to ask you about the research which you are undertaking?

What species of bamboo are you using?

Is the research focused purely on primary structural components (beams and columns) or is the scope, and development of a code of practice, intended to cover secondary building elements also?

The scope of the research is outlined on http://www.arct.cam.ac.uk/, to develop a code of practice for structural design and building construction with structural bamboo products. *Is this code of practice being researched and developed with a means to develop a British or European standard much like those set out for timber products?*

As I have stated above my research is intended to focus on environmental aspects of the selection of engineered bamboo as a building material, however, there is a fundamental question to answer on its structural and mechanical properties so any help, leads or literature in this area would be of great benefit.

I hope that this line of contact could potentially continue and evolve as both our studies continue and I look forward to your reply.

Regards

Philip Kavanagh

>

After this email was sent time was given for a reply. After about 5-6 days there was no reply to the first email a second was written up and sent to the lead researcher Mr. Ramage at Cambridge University.

This email is presented below:

>

Dear Mr. Ramage,

I am just following up on an email which I sent to you last week in regards to the project set out to develop a code of practice for structural design and building construction with Structural Bamboo Products.

With further research into the project I found that the scope of the project seems to relate to other studies going on in Cambridge University the most noteworthy the work being completed by Dr Maximillian Bock.

I would just like to further clarify my research in this email if I may. I do not intend to copyright any ideas that are being conducted by your research and research team. However, this being said I do believe that the study which you and your team are conducting and the study which I am conducting seem to relate. My study although partly and fundamentally relies on structural testing results and mechanical properties it is only a small part of the scope of my project. I simply just want to establish an argument that a bamboo engineered product is equally or better than timber. The main scope of my project for me as an Architectural Technologist is its use as an environmental and sustainable building. My main intention is to develop a model of construction using engineered bamboo products for future sustainable development. I hope the study will focus on major topics like life cycle analysis, sustainability and detailed design rather than the mechanical properties. The point of the original email was to establish contact and try to understand your project further. I hope by doing so I haven't stepped on any toes. If there was a chance for discussion on this area and perhaps an agreement of confidentiality could be perused to ensure that the information is applied correctly and without copyright.

I hope and believe that each study on engineered bamboo is a step in the right direction for sustainable building materials and if this line of contact cannot be continued, for whatever reason, I wish you the best of luck in your research and look forward to one day reading the published results.

Many thanks.

Philip Kavanagh

>

In light of no further reply from Mr Ramage in relation to either email research continued into the scope and parameters of the study at Cambridge. This found further research being conducted by a body of people at Cambridge University in relation to bamboo for sustainable buildings.

Further studies being conducted in Cambridge include one by Dr Maximillian Bock as outlined below.

Bamboo for sustainable building

Dr Maximillian Bock (Department of Architecture) is investigating bamboo as a viable alternative to current building materials to help meet CO_2 emission targets.

The overall aim of this project is to lead architects and engineers to a greener and more sustainable future. Some bamboos are very fast growing, and can reach 60ft to 90ft in the first year, making the genus an ideal candidate for research in sustainable construction practices. Dr Bock is studying the strength and environmental impact of bamboo species to evaluate the potential of different bamboo products for reducing emissions in the construction sector, which accounts for almost 40% of CO_2 emissions globally. This work is part of a wider project run between University of Cambridge, MIT, University of British Columbia and Cambridge Architectural Research study.

Cultivating exotic bamboo species in Europe's climate can be very challenging and therefore Dr Bock sought the assistance of Pete Michna and his students at the Botanic Garden in Cambridge to cultivate a range of common and rarer bamboo species. The different bamboo culms will be subjected to structural tests, once mature (commonly 3 to 5 years after planting).

Dr. Bock was not contacted in relation to his research.

Comments from David Madden and Sebastian Kaminski of Arups

“The data you have received may be misleading and incorrect. Even the data published within the Sharma et al. (2015) paper looks awry. This is because of the following reasons:”

A. “Strengths by inspection are too high for raw bamboo – it is likely that the test methods have been favourable to the shape and anatomy of bamboo and not conducted with standard practice.”
B. “Strengths by inspection appear suspiciously high for the laminated bamboo and bamboo scrimber.”
C. “The strengths presented for the Sitka spruce are on the high side (and much data exists for this).”
D. “There are several ways of determining a material’s characteristic strength, and it may be the case that each of these independent studies has used their own, hence they are not necessarily comparable. Each study may not even be presenting characteristic values.”
E. “The values presented are apparently *characteristic*, which would mean they need to be divided by a healthy safety factor for use. This might be 2-4.”
F. “Reading off the stress-strain curves for compression on page 70 of the Sharma et al. (2015) paper, they appear to have used the plastic values instead of the elastic for the strength – since timber/bamboo is a brittle material, the elastic values should be used, hence their values appear incorrect. This makes me suspicious about their other data.”

“For your purposes, you could either:”

A. “Assume laminated veneer bamboo has identical properties to Douglas-fir LVL.”

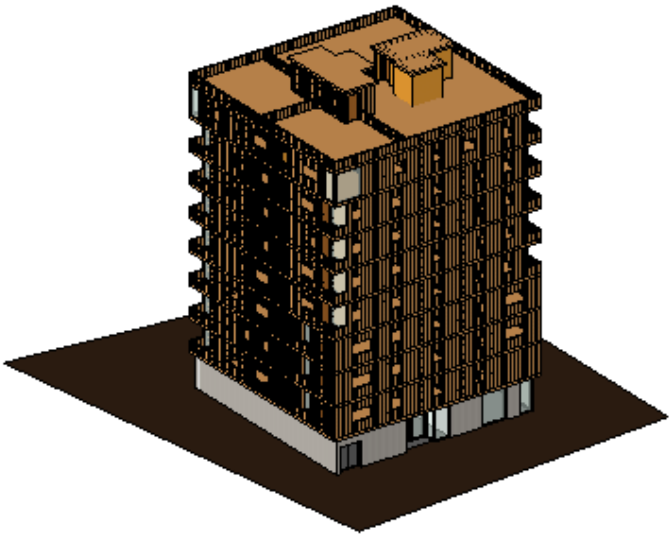
B. “Take the laminated veneer bamboo properties but divided by a healthy factor of safety to get the design values. I would suggest 3 as a minimum.”

Species	Chemical formula	Lifetime (years)	Global Warming Potential (Time Horizon)		
			20 years	100 years	500 years
CO_2	CO_2	variable §	1	1	1
Methane *	CH_4	12±3	56	21	6.5
Nitrous oxide	N_2O	120	280	310	170
HFC-23	CHF3	264	9100	11700	9800
HFC-32	CH2F2	5.6	2100	650	200
HFC-41	CH3F	3.7	490	150	45
HFC-43-10mee	C5H2F10	17.1	3000	1300	400
HFC-125	C2HF5	32.6	4600	2800	920
HFC-134	C2H2F4	10.6	2900	1000	310
HFC-134a	CH2FCF3	14.6	3400	1300	420
HFC-152a	C2H4F2	1.5	460	140	42
HFC-143	C2H3F3	3.8	1000	300	94
HFC-143a	C2H3F3	48.3	5000	3800	1400
HFC-227ea	C3HF7	36.5	4300	2900	950
HFC-236fa	C3H2F6	209	5100	6300	4700
HFC-245ca	C3H3F5	6.6	1800	560	170
Sulphur hexafluoride	SF6	3200	16300	23900	34900
Perfluoromethane	CF4	50000	4400	6500	10000
Perfluoroethane	C2F6	10000	6200	9200	14000
Perfluoropropane	C3F8	2600	4800	7000	10100
Perfluorobutane	C4F10	2600	4800	7000	10100
Perfluorocyclobutane	c-C4F8	3200	6000	8700	12700
Perfluoropentane	C5F12	4100	5100	7500	11000
Perfluorohexane	C6F14	3200	5000	7400	10700

Stadthaus, Murray Grove

Design Option Comparison

10/08/2015



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Report Summary

Created with Tally
Non-commercial Version 2014.06.17.01

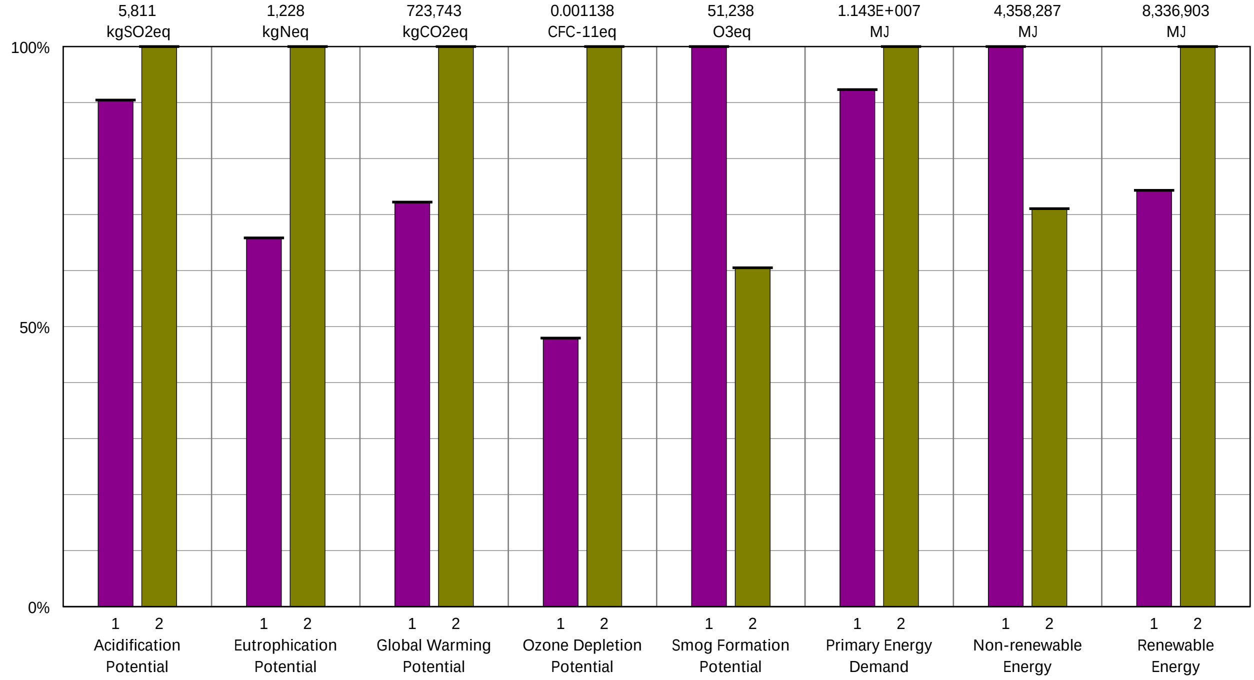
Author : Philip Kavanagh
Company : Dublin Institute of Technology
Date : 10/08/2015

Project : Stadthaus, Murray Grove
Location : London, England
Gross Area : 2782.998 m²
Building Life : 50

Scope : Cradle-to-Grave, exclusive of operational energy

Goal of Assessment :
To determine the global warming potential, through life cycle analysis, of laminated veneer bamboo hybrid construction panels over the selection of cross laminated timber panels for use in high density, high rise resedential accommodation.

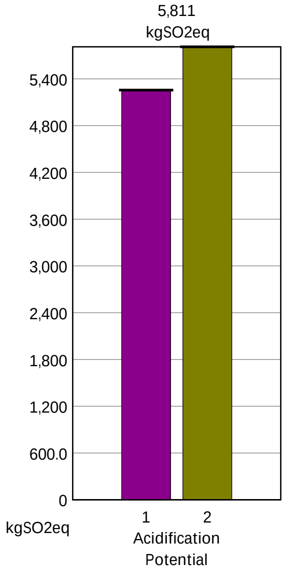
Object of Study
Design options set 'Option Set 1'
Bamboo LVB Hybrid Box (primary)
Cross Laminated Timber

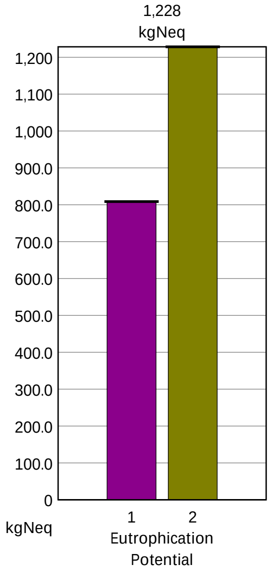


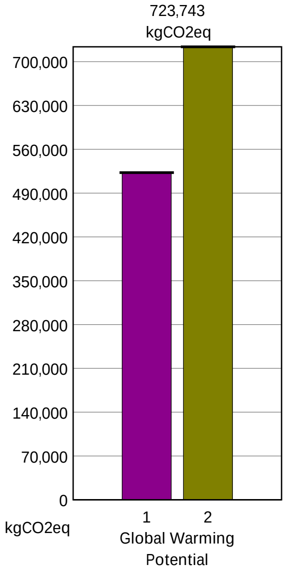
Legend

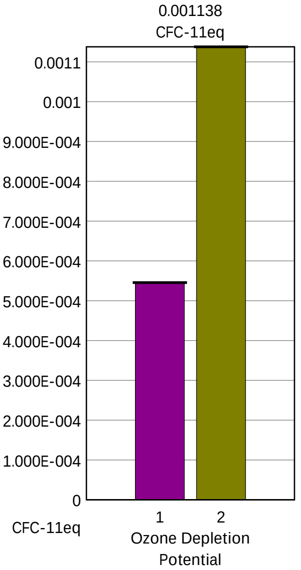
Design Options
Bamboo LVB Hybrid Box (primary)
Cross Laminated Timber

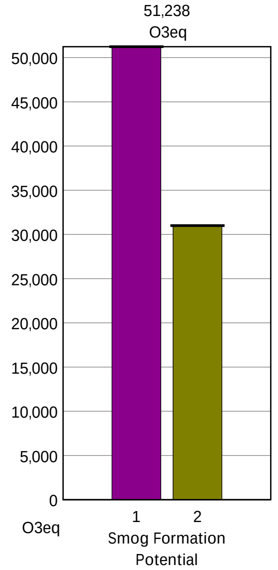
Report Summary (continued)

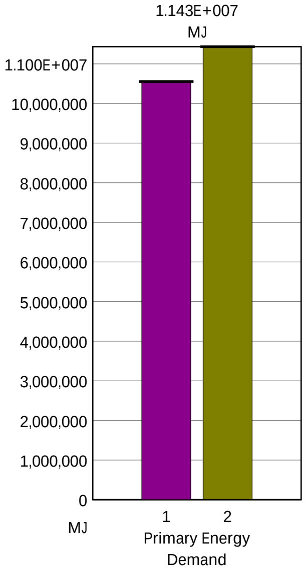


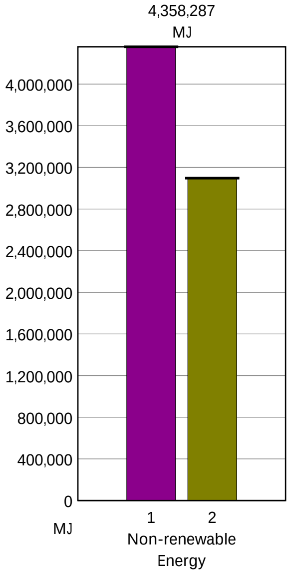


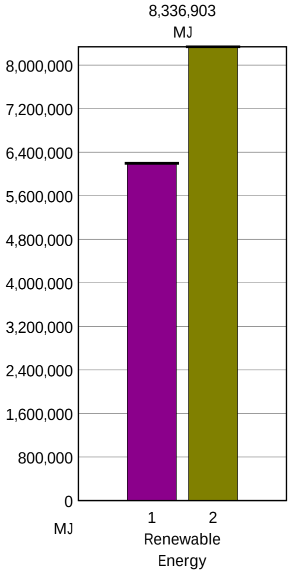










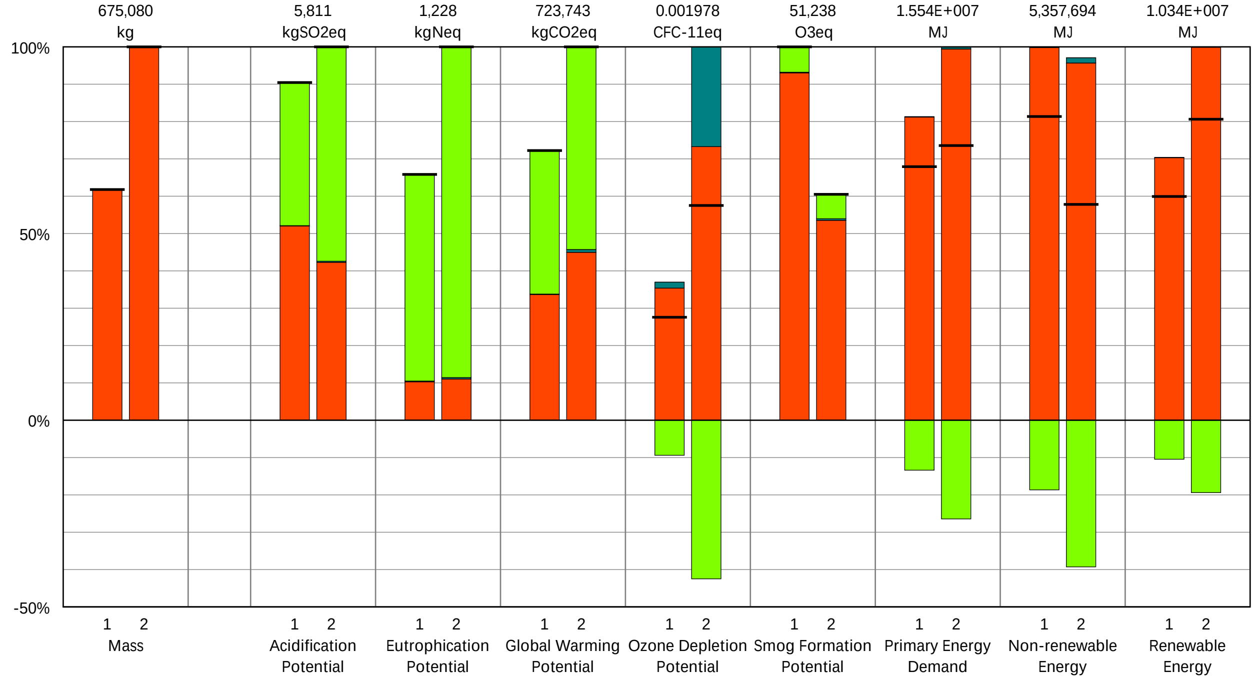


Legend

Design Options

- Bamboo LVB Hybrid Box (primary)
- Cross Laminated Timber

Results per Life Cycle Stage



Legend

Net value (impacts + credits)

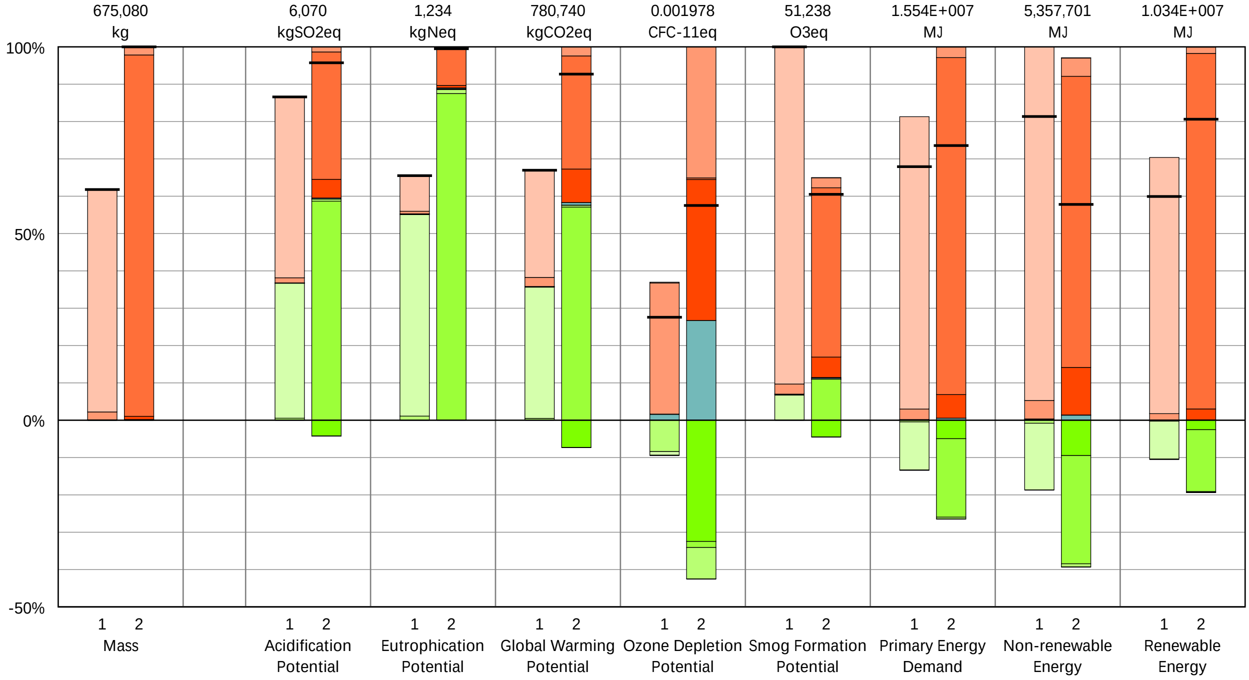
Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)
Option 2 - Cross Laminated Timber

Life Cycle Stages

Manufacturing
Maintenance and Replacement
End of Life

Results per Life Cycle Stage, itemized by CSI Division



Legend

Net value (impacts + credits)

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)
Option 2 - Cross Laminated Timber

Manufacturing

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

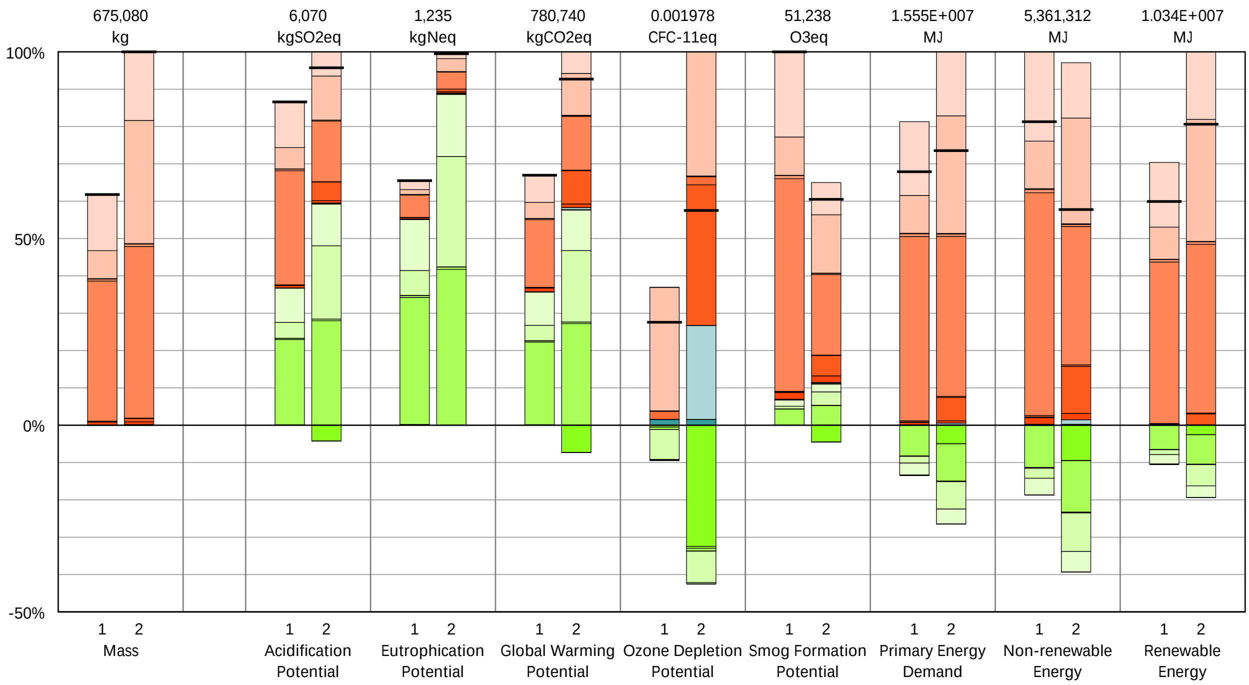
Maintenance and Replacement

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

End of Life

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

Results per Life Cycle Stage, itemized by Revit Category



Legend

Net value (impacts + credits)

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Manufacturing

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

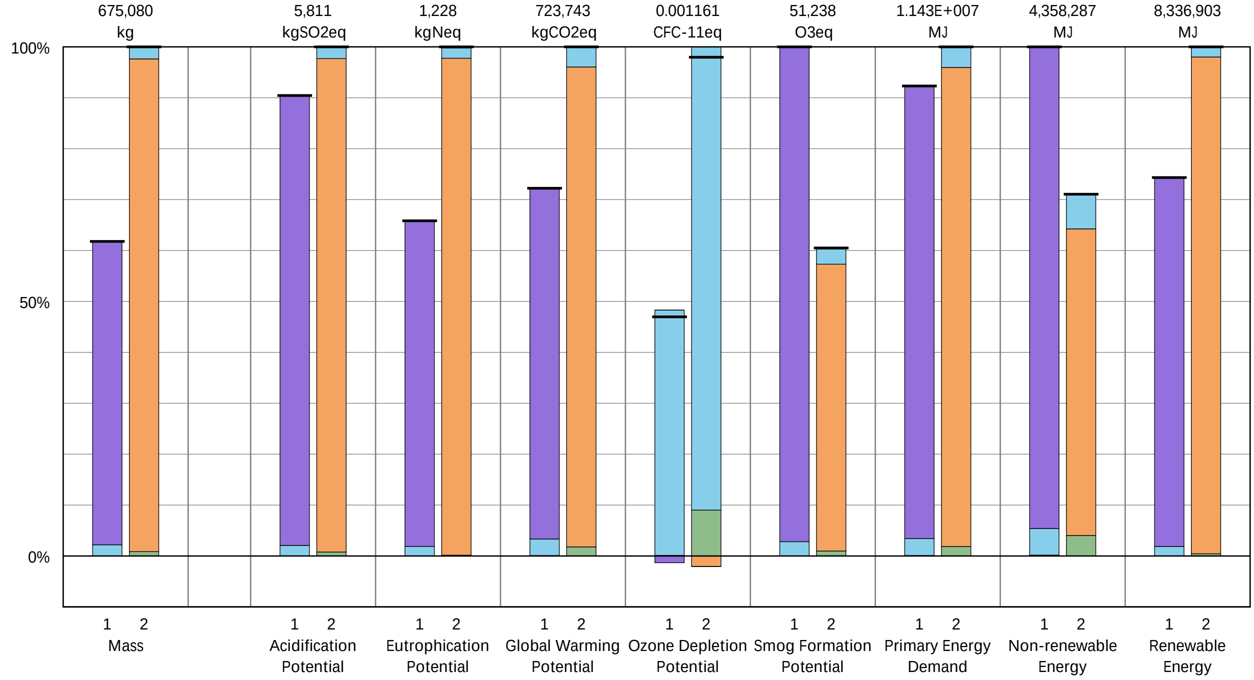
Maintenance and Replacement

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

End of Life

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per CSI Division



Legend

Design Options

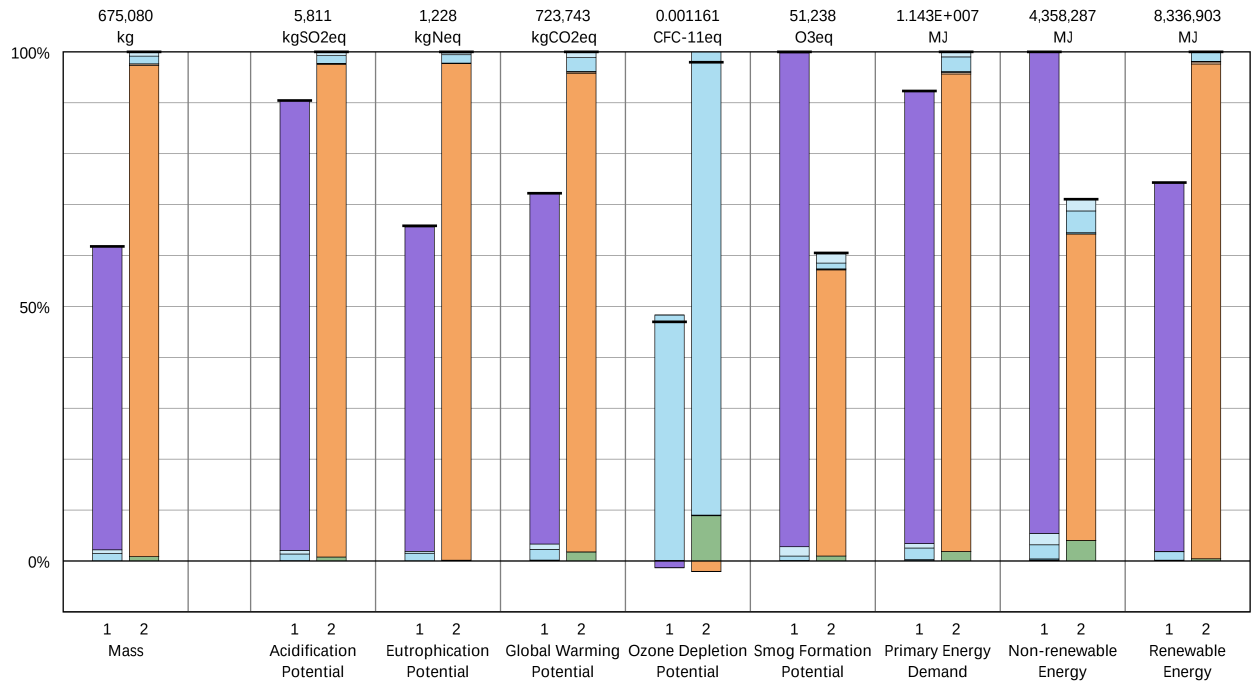
Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

CSI Divisions

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

Results per CSI Division, itemized by Tally Entry



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

05 - Metals

- Aluminum, extrusion
- Stainless steel, hardware

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam / CLT)
- Domestic softwood

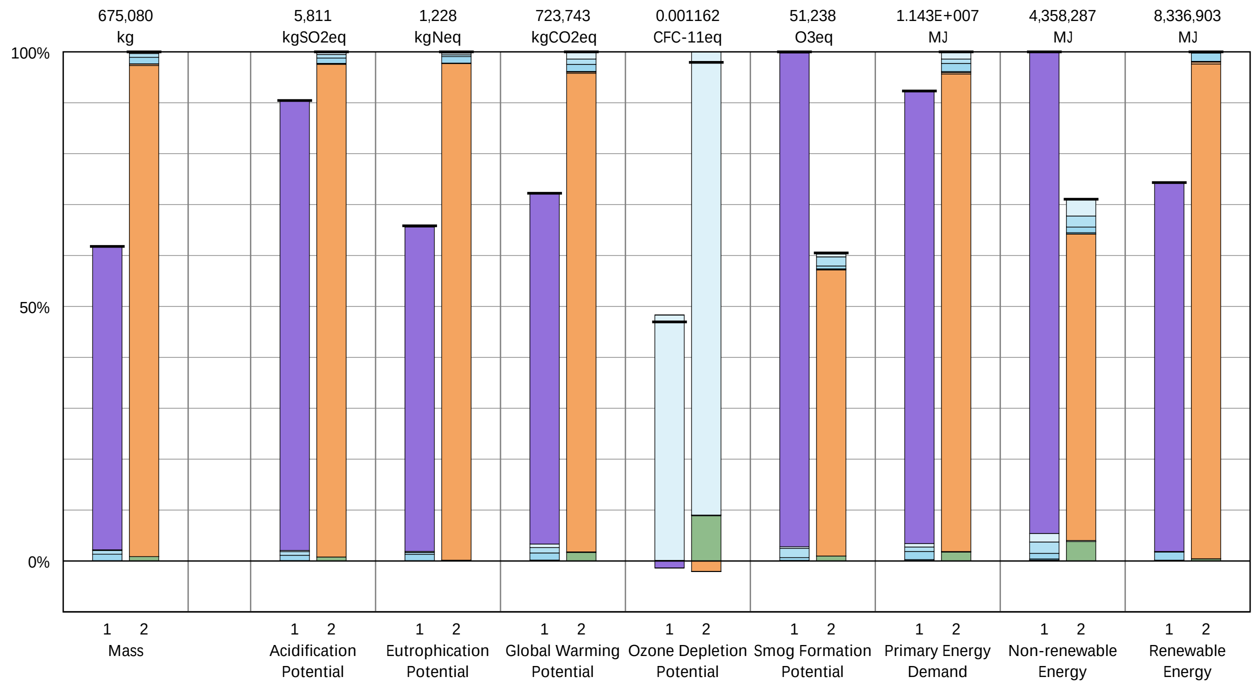
08 - Openings and Glazing

- Door frame, wood
- Door, interior, wood, MDF core, flush
- Glazing, triple pane IGU

09 - Finishes

- Flooring, bamboo plank
- Flooring, engineered wood plank

Results per CSI Division, itemized by Material



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

05 - Metals

- Aluminum, extruded
- Hardware, stainless steel
- Powder coating, metal stock

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam)
- Domestic softwood, US
- None
- Paint, interior acrylic latex

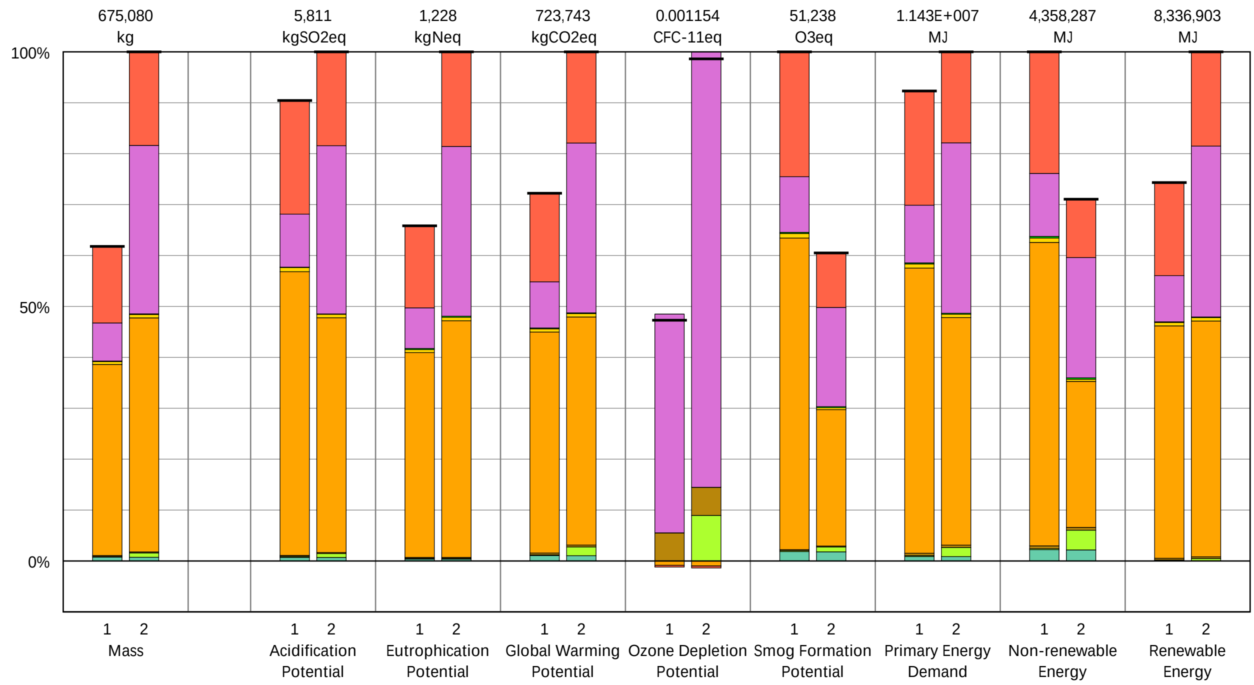
08 - Openings and Glazing

- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Glazing, triple, insulated (argon), low-E
- None
- Stainless steel, door hardware, lever lock, interior, residential

09 - Finishes

- Flooring, bamboo plank
- Interior grade plywood, US
- None
- Polyurethane floor finish, water-based
- Veneer, hardwood

Results per Revit Category



Legend

Design Options

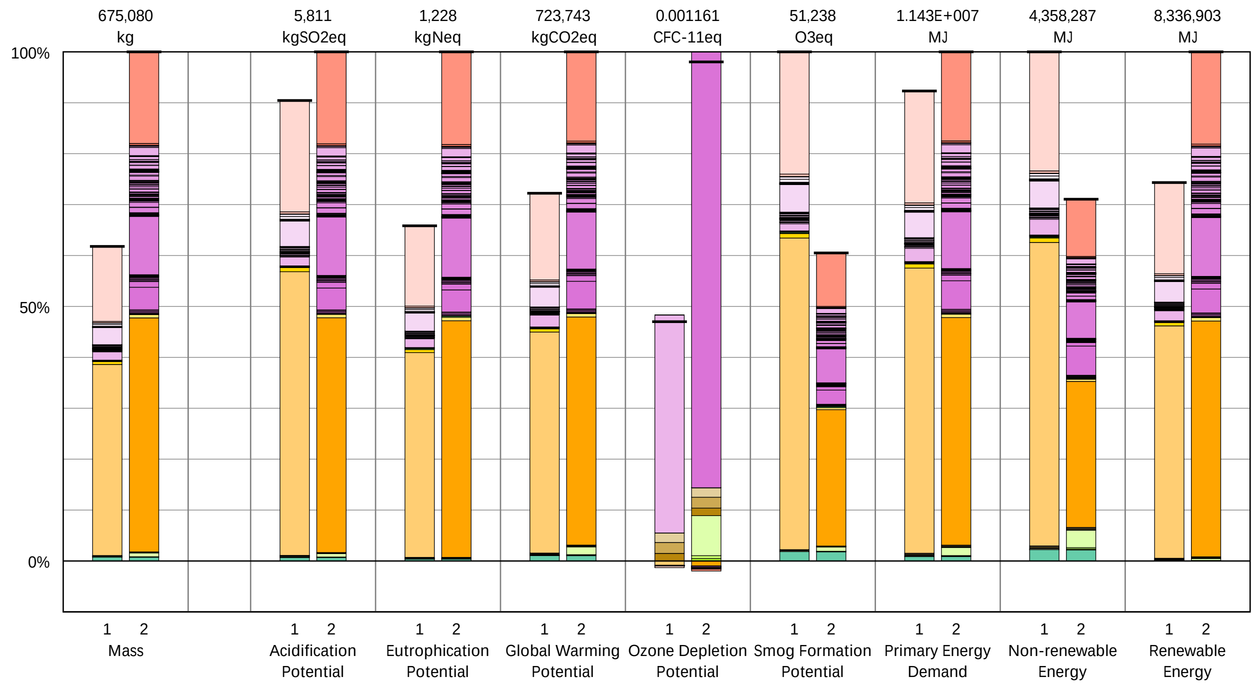
Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Revit Categories

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per Revit Category, itemized by Family



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- System Panel: Glazed

Curtain Wall Mullions

- Quad Corner Mullion: Quad Mullion 1
- Quad Corner Mullion: Quad Mullion Bamboo
- Rectangular Mullion: 50 x 120mm
- Rectangular Mullion: 50 x 120mm Bamboo
- Rectangular Mullion: 50 x 150mm
- Rectangular Mullion: 50 x 150mm Bamboo

Doors

- IntSgl (7): 1010 x 2110mm
- IntSgl (7): 810 x 2110mm
- IntSgl (7): 910 x 2110mm

Floors

- CLT Timber
- LVB Bamboo Floor

Roofs

- Bamboo LVB
- Cross Laminated Timber CLT

Stairs and Railings

- 1100mm
- Stair

Structure

- CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel
- CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel
- CLT Corner Panel: CLT Corner Panel Full Height NE-SE
- CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door
- CLT Door Ope 900mm: CLT Door Ope 900mm
- CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1820mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1022mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1058mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1070mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1100mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1738mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1850mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1860mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm 2
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1886mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1918mmx2440mm

Results per Revit Category, itemized by Family (continued)

Legend (continued)

- CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1932mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1941mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1942mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1996mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2038mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2064mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2111mmx2440mm
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- CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm
- CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus Half 1260mm
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- Corner Balcony Panel SW-NW 732mm height: Corner Balcony Panel SW-NW 732mm h
- Corner Panel NE Corner: Corner Panel NE Corner
- Door ope Panel 2440mmx1220mm w-900x2110 No Door: Door ope Panel 2440mmx12 n.
- Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx1220m 9.
- Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx1220mm
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- Half Panel Single 230mm Width: Half Panel Single 270mm Width
- Half Panel Single 230mm Width: Half Panel Single 310mm Width
- Half Panel Single 230mm Width: Half Panel Single 390mm Width
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- Single Box 230mmx2440mm: Single Box 132mmx2440mm
- Single Box 230mmx2440mm: Single Box 147mmx2440mm
- Single Box 230mmx2440mm: Single Box 151mmx2440mm
- Single Box 230mmx2440mm: Single Box 152mmx2440mm
- Single Box 230mmx2440mm: Single Box 163.2mmx2440mm
- Single Box 230mmx2440mm: Single Box 191mmx2440mm
- Single Box 230mmx2440mm: Single Box 207mmx2440mm
- Single Box 230mmx2440mm: Single Box 221mmx2440mm
- Single Box 230mmx2440mm: Single Box 223.1mmx2440mm
- Single Box 230mmx2440mm: Single Box 228mmx2440mm
- Single Box 230mmx2440mm: Single Box 230mmx2440mm
- Single Box 230mmx2440mm: Single Box 231mmx2440mm
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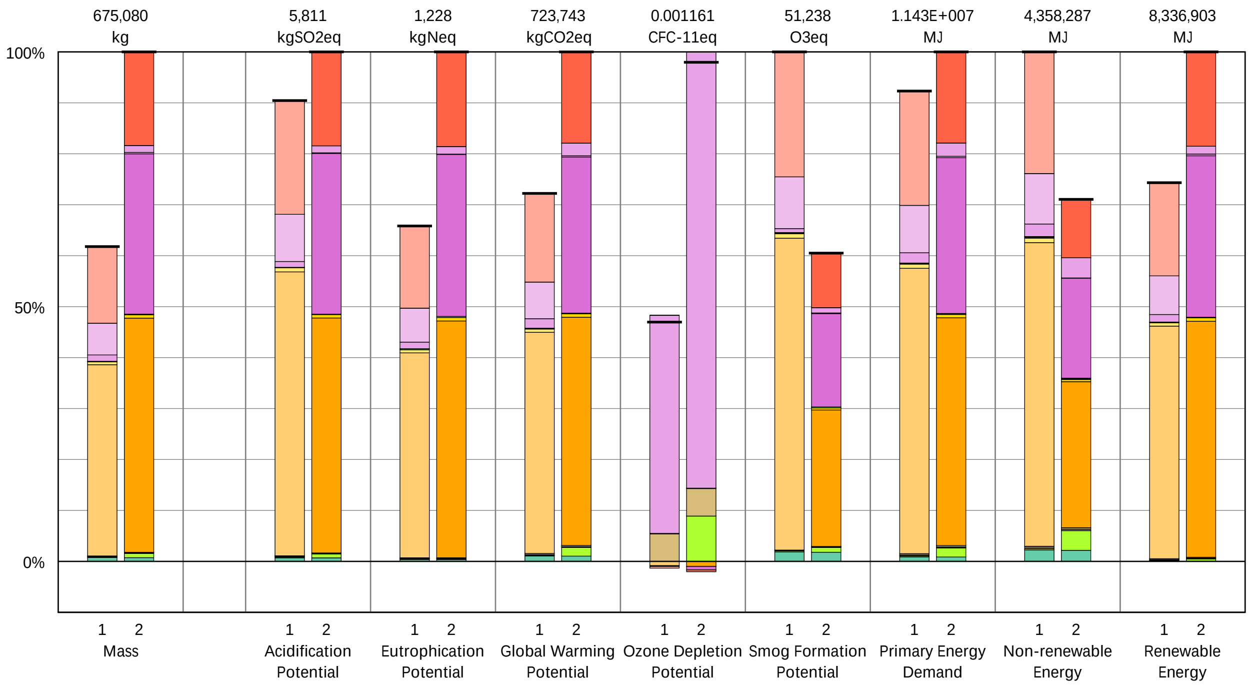
- Single Box 230mmx2440mm: Single Box 320mmx2440mm
- Single Box 230mmx2440mm: Single Box 327mmx2440mm
- Single Box 230mmx2440mm: Single Box 330.2mmx2440mm
- Single Box 230mmx2440mm: Single Box 331mmx2440mm
- Single Box 230mmx2440mm: Single Box 350mmx2440mm
- Single Box 230mmx2440mm: Single Box 355mmx2440mm
- Single Box 230mmx2440mm: Single Box 358mmx2440mm
- Single Box 230mmx2440mm: Single Box 432mmx2440mm
- Single Box 230mmx2440mm: Single Box 80mmx2440mm
- Single End Sheet 120mmx2440mmx12mm: Single End Sheet 120mmx2440mmx12mm
- Window Ope Center 910mm: Window Ope Center 910mm
- Window Ope Offset 910mm: Window Ope offset 910mm
- Window Ope Offset Half Window: Window Ope Offset Half Window

Walls

- Cross Laminated Timber Mass 100mm
- Cross Laminated Timber Mass 188mm
- Cross Laminated Timber Mass 300
- Generic Bamboo Mass 100
- Generic Bamboo Mass 188mm
- Generic Bamboo Mass 300

Results per Revit Category, itemized by Tally Entry



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- Glazing, triple pane IGU

Curtain Wall Mullions

- Aluminum, extrusion
- Flooring, bamboo plank

Doors

- Domestic softwood
- Door frame, wood
- Door, interior, wood, MDF core, flush
- Stainless steel, hardware

Floors

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Roofs

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Stairs and Railings

- Aluminum, extrusion
- Flooring, engineered wood plank

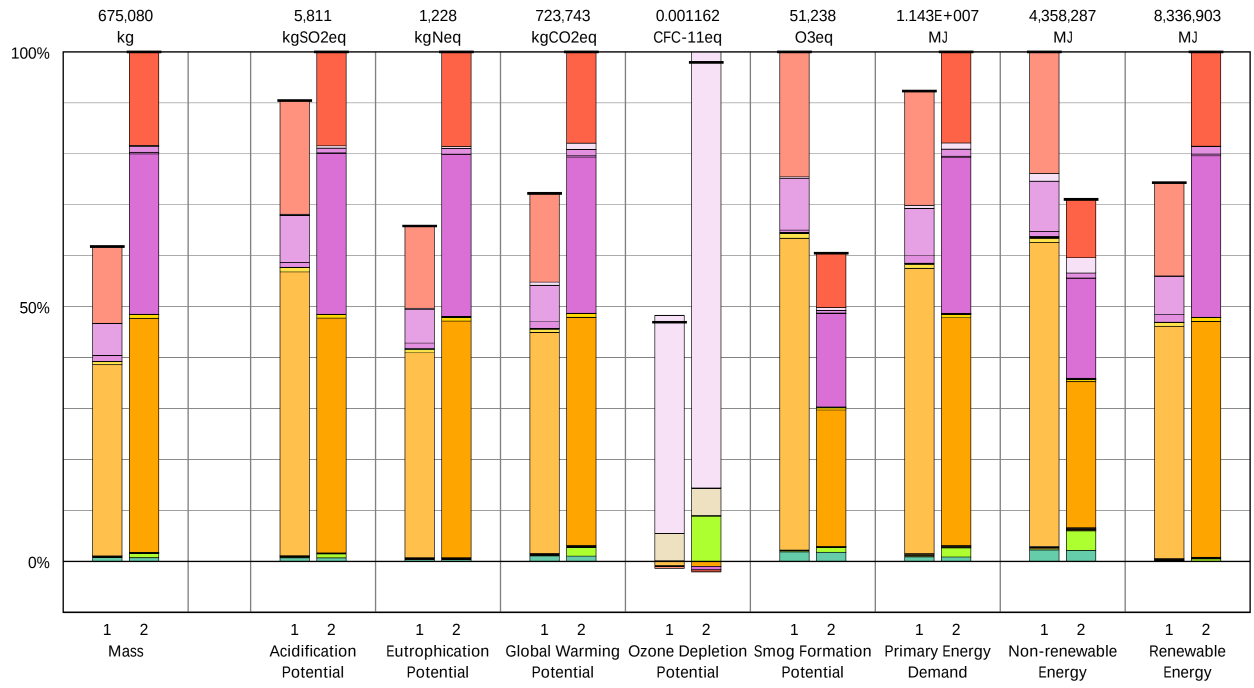
Structure

- Cross laminated timber (CrossLam / CLT)
- Domestic softwood
- Door, interior, wood, MDF core, flush
- Flooring, bamboo plank
- Stainless steel, hardware

Walls

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Results per Revit Category, itemized by Material



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- Glazing, triple, insulated (argon), low-E

Curtain Wall Mullions

- Aluminum, extruded
- Flooring, bamboo plank
- None
- Powder coating, metal stock

Doors

- Domestic softwood, US
- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Hardware, stainless steel
- None
- Stainless steel, door hardware, lever lock, interior, residential

Floors

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Roofs

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Stairs and Railings

- Aluminum, extruded
- Interior grade plywood, US
- None
- Polyurethane floor finish, water-based
- Powder coating, metal stock
- Veneer, hardwood

Structure

- Cross laminated timber (CrossLam)
- Domestic softwood, US
- Door, interior, wood, MDF Core, flush
- Flooring, bamboo plank
- Hardware, stainless steel
- None
- Paint, interior acrylic latex
- Stainless steel, door hardware, lever lock, interior, residential

Walls

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Calculation Methodology

Studied objects

The LCA results in the report represent either an analysis of a single building, or a comparative analysis of two or more building design options. The single building may represent the complete architectural, structural, and finish systems of a building or a subset of those systems, and it may be used to compare the relative contributions of building systems to environmental impacts and for comparative study with one or more reference buildings. The comparison of design options may represent a full building in various stages of the design process, or they may represent multiple schemes of a full or partial building that are being compared to one another across a range of evaluation criteria.

Functional unit and reference flow

The functional unit of the analysis is the usable floor space of the building under study. For a design option comparison of a partial building, the functional unit is the complete set of building systems that performs a given function. The reference flow is the amount of material required to produce a building, or portion thereof, designed according to the given goal and scope of the assessment, over the full life of the building. If operational energy is included in the assessment the reference flow also includes the electrical and thermal energy consumed on site over the life of the building. It is the responsibility of the modeler to assure that reference buildings or design options are functionally equivalent in terms of scope, size, and relevant performance. The expected life of the building has a default value of 60 years and can be modified by the model author.

System boundaries and delimitations

The analysis accounts for the full cradle-to-grave life cycle of the design options studied, including material manufacturing, maintenance and replacement, and eventual end-of-life (disposal, incineration, and/or recycling), including the materials and energy used across all life cycle stages. Optionally, the operational energy of the building can be included within the scope.

Architectural materials and assemblies include all materials required for the product’s manufacturing and use (including hardware, sealants, adhesives, coatings, and finishing, etc.) up to a 1% cut-off factor by mass with the exception of known materials that have high environmental impacts at low levels. In these cases, a 1% cut-off was implemented by impact.

Manufacturing includes cradle-to-gate manufacturing wherever possible. This includes raw material extraction and processing, intermediate transportation, and final manufacturing and assembly. Due to data limitations, however, some manufacturing steps have been excluded, such as the material and energy requirements for assembling doors and windows. The manufacturing scope is listed for each entry, detailing any specific inclusions or exclusions that fall outside of the cradle-to-gate scope.

Transportation of upstream raw materials or intermediate products to final manufacturing is generally included in the GaBi datasets utilized within this tool. Transportation requirements between the manufacturer and installation of the product, and at the end-of-life of the product, are excluded from this study.

Infrastructure (buildings and machinery) required for the manufacturing and assembly of building materials, as well as packaging materials, are not included and are considered outside the scope of assessment.

Maintenance and replacement encompasses the replacement of materials in accordance with the expected service life. This includes the end-of-life treatment of the existing products and cradle-to-gate manufacturing of the replacement products. The service life is specified separately for each product.

Operational energy treatment is based on the anticipated energy consumed at the building site over the lifetime of the building. Each energy dataset includes relevant upstream impacts associated with extraction of energy resources (e.g., coal, crude oil), refining, combustion, transmission, losses, and other associated factors. US electricity generation datasets are based on subregions from US EPA's eGRID2012 database v1.0, but adapted to account for imports and exports into these regions. These consumption mixes - unique to the GaBi databases - provide a more accurate reflection of impacts associated with electricity consumption.

End-of-life treatment is based on average US construction and demolition waste treatment methods and rates. This includes the relevant material collection rates for recycling, processing requirements for recycled materials, incineration rates, and landfilling rates. Along with processing requirements, the recycling of materials is modeled using an avoided burden approach, where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material. Incineration of materials includes credit for average US energy recovery rates. The impacts associated with landfilling are based on average material properties, such as plastic waste, biodegradable waste, or inert material. Specific end-of-life scenarios are detailed for each entry.

Data source and quality

Tally utilizes a custom designed LCA database that combines material attributes, assembly details, and engineering and architectural specifications with environmental impact data resulting from the collaboration between KieranTimberlake and PE INTERNATIONAL. LCA modeling was conducted in GaBi 6 using GaBi databases and in accordance with GaBi database and modeling principles.

Geography and date: The data used are intended to represent the US and the year 2013. Where representative data were unavailable, proxy data were used. The datasets used, their geographic region, and year of reference are listed for each entry. An effort was made to choose proxy datasets that are technologically consistent with the relevant entry.

Uncertainty in results can stem from both the data used and the application of the data. Data quality is judged by its precision (measured, calculated, or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological). The LCI data sets from the GaBi LCI databases have been used in LCA models worldwide in industrial and scientific applications, both as internal and critically reviewed and published studies. The uncertainty introduced by the use of any proxy data is reduced by using technologically, geographically, and/or temporally similar data. It is the responsibility of the modeler to apply the predefined material entries appropriately to the building under study.

Tally methodology is consistent with LCA standards ISO 14040-14044.

Glossary of LCA Terminology

Environmental Impact Categories

The following list provides a description of environmental impact categories reported according to the TRACI 2.1 characterization scheme. References: [Bare 2010, EPA 2012, Guinée 2001]

Acidification Potential (AP) kg SO2 eq

A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline, and the deterioration of building materials.

Eutrophication Potential (EP) kg N eq

Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.

Global Warming Potential (GWP) kg CO2 eq

A measure of greenhouse gas emissions, such as CO2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health, and material welfare.

Ozone Depletion Potential (ODP) kg CFC-11 eq

A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants.

Smog Formation Potential (SFP) kg O3 eq

Ground level ozone is created by various chemical reactions, which occur between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in sunlight. Human health effects can result in a variety of respiratory issues including increasing symptoms of bronchitis, asthma, and emphysema. Permanent lung damage may result from prolonged exposure to ozone. Ecological impacts include damage to various ecosystems and crop damage. The primary sources of ozone precursors are motor vehicles, electric power utilities, and industrial facilities.

Primary Energy Demand (PED) MJ (lower heating value)

A measure of the total amount of primary energy extracted from the earth. PED is expressed in energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.) and energy demand from renewable resources (e.g. hydropower, wind energy, solar, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account.

LCA Metadata

NOTES

The following list provides a summary of all materials and energy inputs present in the selected study. Materials are listed in alphabetical order along with a list of all Revit families and Tally entries in which they occur and any notes and system boundaries accompanying their database entries. The mass given here refers to the full life-cycle mass of material, including manufacturing and replacement.

Aluminum, extruded	**5,733.6 kg**

Used in the following Revit families:

1100mm	0.0 kg
Quad Corner Mullion: Quad Mullion 1	297.8 kg
Rectangular Mullion: 50 x 120mm	368.1 kg
Rectangular Mullion: 50 x 150mm	5,067.7 kg

Used in the following Tally entries:
Aluminum, extrusion

Description:
Extruded aluminum part

Life Cycle Inventory:
Aluminum, process energy

Manufacturing Scope:
Cradle to gate

End of Life Scope:
95% recovered (includes recycling, scrap preparation, and avoided burden credit)
5% landfilled (inert material)

Entry Source:
NA: Primary Aluminium Ingot AA (2011)
EU-27: Aluminium extrusion profile PE (2012)

Cross laminated timber (CrossLam)	**651,180.5 kg**

Used in the following Revit families:

CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel	910.9 kg
CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel	1,495.9 kg
CLT Corner Panel: CLT Corner Panel Full Height NE-SE	1,649.4 kg
CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door	1,400.1 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	18,733.8 kg
CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1...	7,580.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm	430.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1022mmx2440mm	1,612.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1058mmx2440mm	303.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1070mmx2440mm	153.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1100mmx2440mm	1,420.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1123mmx2440mm	1,450.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1127mmx2440mm	485.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1130mmx2440mm	810.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1145mmx2440mm	492.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1160mmx2440mm	332.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1192mmx2440mm	684.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1219mmx2440mm	874.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1220mmx2440mm	77,365.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1232mmx2440mm	176.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1252mmx2440mm	179.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1274mmx2440mm	365.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1300mmx2440mm	559.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1305mmx2440mm	187.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1340mmx2440mm	384.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1342mmx2440mm	192.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1352mmx2440mm	387.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1367mmx2440mm	196.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1383mmx2440mm	595.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1427mmx2440mm	1,023.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1435mmx2440mm	205.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1448mmx2440mm	415.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1450mmx2440mm	7,073.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1455mmx2440mm	208.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 151mmx2440mm	86.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1547mmx2440mm	6,436.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm	1,556.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1578mmx2440mm	226.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1652mmx2440mm	474.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1702mmx2440mm	732.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1738mmx2440mm	249.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1740mmx2440mm	748.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1762mmx2440mm	252.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1764mmx2440mm	759.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1766mmx2440mm	253.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1800mmx2440mm	258.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1850mmx2440mm	2,123.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1860mmx2440mm	800.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm	1,080.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm 2	810.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1886mmx2440mm	811.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1918mmx2440mm	1,651.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm	27.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1932mmx2440mm	277.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1941mmx2440mm	557.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1942mmx2440mm	3,900.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1944mmx2440mm	278.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1954mmx2440mm	2,803.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1996mmx2440mm	2,004.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm	870.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2038mmx2440mm	1,754.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2049mmx2440mm	881.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2056mmx2440mm	884.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2062mmx2440mm	295.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2064mmx2440mm	296.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2111mmx2440mm	1,211.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2196mmx2440mm	315.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2380mmx2440mm	5,463.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2440mmx2440mm	1,400.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2492mmx2440mm	3,575.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2760mmx2440mm	396.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 290mmx2440mm	41.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 350mmx2440mm	200.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 462mmx2440mm	66.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 496mmx2440mm	71.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 538mmx2440mm	154.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 543mmx2440mm	311.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 556mmx2440mm	159.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 559mmx2440mm	240.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 616.2mmx2440mm	884.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 620mmx2440mm	89.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 640mmx2440mm	550.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 670mmx2440mm	384.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 682mmx2440mm	195.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 700mmx2440mm	401.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 710mmx2440mm	407.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 750mmx2440mm	4,842.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 772mmx2440mm	332.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 830mmx2440mm	3,334.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 842mmx2440mm	1,087.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 876.9mmx2440mm	377.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 896mmx2440mm	128.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 930mmx2440mm	266.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 950mmx2440mm	2,044.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 978mmx2440mm	140.3 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1220mmx732mm	3,990.8 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1320mmx732mm	56.8 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1490mmx732mm	513.1 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1530mmx732mm	65.9 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1610mmx732mm	485.1 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1990mmx732mm	85.7 kg
CLT Timber	310,291.5 kg
CLT Window Ope Center 910mm: CLT Window Ope Center 910mm	10,865.5 kg
CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm	1,516.1 kg
CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus ...	1,132.7 kg
Cross Laminated Timber CLT	4,582.3 kg
Cross Laminated Timber Mass 100mm	246.3 kg
Cross Laminated Timber Mass 188mm	2,341.2 kg
Cross Laminated Timber Mass 300	121,448.8 kg

Used in the following Tally entries:
Cross laminated timber (CrossLam / CLT)

Description:
PROXIED by LVL

Life Cycle Inventory:
43% PNW
57% SE
Proxied by LVL

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

LCA Metadata (continued)

Entry Source:
US: Laminated veneer lumber, at plant, US PNW USLCI/PE (2009)
US: Laminated veneer lumber, at plant, US SE USLCI/PE (2009)

Domestic softwood, US — 2,279.0 kg

Used in the following Revit families:

CLT Door Ope 900mm: CLT Door Ope 900mm	1,973.6 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	0.0 kg
IntSgl (7): 1010 x 2110mm	74.4 kg
IntSgl (7): 810 x 2110mm	128.8 kg
IntSgl (7): 910 x 2110mm	102.2 kg

Used in the following Tally entries:
Domestic softwood

Description:
Dimensional lumber, sawn, planed, dried and cut for standard framing or planking

Life Cycle Inventory:
38% PNW
62% SE
Dimensional lumber

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Surfaced dried lumber, at planer mill, PNW USLCI/PE (2009)
US: Surfaced dried lumber, at planer mill, SE USLCI/PE (2009)

Door frame, wood, no door — 279.1 kg

Used in the following Revit families:

IntSgl (7): 1010 x 2110mm	68.0 kg
IntSgl (7): 810 x 2110mm	117.7 kg
IntSgl (7): 910 x 2110mm	93.4 kg

Used in the following Tally entries:
Door frame, wood

Description:
Wood door frame

Life Cycle Inventory:
Dimensional lumber

Manufacturing Scope:
Cradle to gate, excludes hardware, jamnb, casing, sealant

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
DE: Wooden frame (EN15804 A1-A3) PE (2012)

Door, interior, wood, MDF Core, flush — 17,316.4 kg

Used in the following Revit families:

CLT Door Ope 900mm: CLT Door Ope 900mm	7,689.4 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	7,689.4 kg
IntSgl (7): 1010 x 2110mm	523.0 kg
IntSgl (7): 810 x 2110mm	754.9 kg
IntSgl (7): 910 x 2110mm	659.7 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Interior flush wood door with MDF core

Life Cycle Inventory:
12.2 kg/m² Wood, 0.052 m3/m3 MDF

Manufacturing Scope:
Cradle to gate, excludes assembly, frame, hardware, and adhesives

End of Life Scope:
14.5% wood products recovered (credited as avoided burden)
22% wood products incinerated with energy recovery
63.5% wood products landfilled (wood product waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)
DE: Wood fibre board PE (2012)

Flooring, bamboo plank — 401,475.7 kg

Used in the following Revit families:

Bamboo LVB	3,740.6 kg
Corner Balcony Panel SE-NE 732mmx120mm: Corner Balcony Panel SE-NE ...	189.9 kg
Corner Balcony Panel SW-NW 732mm height: Corner Balcony Panel SW-NW...	309.0 kg
Corner Panel NE Corner: Corner Panel NE Corner	323.3 kg
Door ope Panel 2440mmx1220mm w-900x2110 No Door: Door ope Panel 244...	338.7 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	2,663.2 kg
Generic Bamboo Mass 100	201.0 kg
Generic Bamboo Mass 188mm	1,911.2 kg
Generic Bamboo Mass 300	99,383.2 kg
Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx1...	1,030.5 kg
Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx7...	7.5 kg
Half Panel Single 230mm Width: Half Panel Single 100mm Width	1.4 kg
Half Panel Single 230mm Width: Half Panel Single 270mm Width	21.8 kg
Half Panel Single 230mm Width: Half Panel Single 310mm Width	3.0 kg
Half Panel Single 230mm Width: Half Panel Single 390mm Width	25.5 kg
LVB Bamboo Floor	253,312.6 kg
LVB Panel Full Size: LVB Panel 1000mm Width	87.1 kg
LVB Panel Full Size: LVB Panel 1022mm Width	325.2 kg
LVB Panel Full Size: LVB Panel 1058mm Width	60.8 kg
LVB Panel Full Size: LVB Panel 1070mm Width	30.7 kg
LVB Panel Full Size: LVB Panel 1100mm Width	941.6 kg
LVB Panel Full Size: LVB Panel 1130mm Width	128.4 kg
LVB Panel Full Size: LVB Panel 1145mm Width	129.8 kg
LVB Panel Full Size: LVB Panel 1160mm Width	655.9 kg
LVB Panel Full Size: LVB Panel 1192mm Width	134.2 kg
LVB Panel Full Size: LVB Panel 520mm Width	17.4 kg
LVB Panel Full Size: LVB Panel 538mm Width	18.2 kg
LVB Panel Full Size: LVB Panel 546mm Width	18.4 kg
LVB Panel Full Size: LVB Panel 554mm Width	37.2 kg
LVB Panel Full Size: LVB Panel 616.2mm Width	200.6 kg
LVB Panel Full Size: LVB Panel 616mm Width	20.1 kg
LVB Panel Full Size: LVB Panel 620mm Width	20.1 kg
LVB Panel Full Size: LVB Panel 630mm Width	163.0 kg
LVB Panel Full Size: LVB Panel 662mm Width	42.3 kg
LVB Panel Full Size: LVB Panel 666mm Width	63.7 kg
LVB Panel Full Size: LVB Panel 670mm Width	85.3 kg
LVB Panel Full Size: LVB Panel 682mm Width	43.2 kg
LVB Panel Full Size: LVB Panel 698mm Width	153.8 kg
LVB Panel Full Size: LVB Panel 710mm Width	111.3 kg
LVB Panel Full Size: LVB Panel 712mm Width	22.3 kg
LVB Panel Full Size: LVB Panel 722mm Width	338.0 kg
LVB Panel Full Size: LVB Panel 724mm Width	45.2 kg
LVB Panel Full Size: LVB Panel 730mm Width	22.7 kg
LVB Panel Full Size: LVB Panel 734mm Width	228.1 kg
LVB Panel Full Size: LVB Panel 750mm Width	1,043.5 kg
LVB Panel Full Size: LVB Panel 772mm Width	165.9 kg
LVB Panel Full Size: LVB Panel 776mm Width	142.8 kg
LVB Panel Full Size: LVB Panel 803mm Width	73.3 kg
LVB Panel Full Size: LVB Panel 818mm Width	148.7 kg
LVB Panel Full Size: LVB Panel 829mm Width	75.1 kg
LVB Panel Full Size: LVB Panel 830mm Width	1,127.9 kg
LVB Panel Full Size: LVB Panel 832mm Width	200.9 kg
LVB Panel Full Size: LVB Panel 836mm Width	100.8 kg
LVB Panel Full Size: LVB Panel 842mm Width	354.8 kg
LVB Panel Full Size: LVB Panel 876.9mm Width	52.3 kg
LVB Panel Full Size: LVB Panel 877mm Width	26.2 kg
LVB Panel Full Size: LVB Panel 891mm Width	53.0 kg
LVB Panel Full Size: LVB Panel 900mm Width	53.4 kg
LVB Panel Full Size: LVB Panel 930mm Width	82.2 kg
LVB Panel Full Size: LVB Panel 950mm Width	446.0 kg
LVB Panel Full Size: LVB Panel 976mm Width	28.5 kg
LVB Panel Full Size: LVB Panel 978mm Width	28.5 kg
LVB Panel Full Size: LVB Panel Full Size	22,605.6 kg
Quad Corner Mullion: Quad Mullion Bamboo	43.9 kg
Rectangular Mullion: 50 x 120mm Bamboo	54.3 kg
Rectangular Mullion: 50 x 150mm Bamboo	756.1 kg
Single Box 230mmx2440mm: Single Box 120mmx2440mm	15.2 kg
Single Box 230mmx2440mm: Single Box 122mmx2440mm	5.1 kg
Single Box 230mmx2440mm: Single Box 132mmx2440mm	10.7 kg
Single Box 230mmx2440mm: Single Box 147mmx2440mm	5.7 kg
Single Box 230mmx2440mm: Single Box 151mmx2440mm	23.1 kg

LCA Metadata (continued)

Single Box 230mmx2440mm: Single Box 152mmx2440mm	5.8 kg
Single Box 230mmx2440mm: Single Box 163.2mmx2440mm	18.2 kg
Single Box 230mmx2440mm: Single Box 191mmx2440mm	6.7 kg
Single Box 230mmx2440mm: Single Box 207mmx2440mm	35.5 kg
Single Box 230mmx2440mm: Single Box 221mmx2440mm	14.9 kg
Single Box 230mmx2440mm: Single Box 223.1mmx2440mm	29.9 kg
Single Box 230mmx2440mm: Single Box 228mmx2440mm	15.2 kg
Single Box 230mmx2440mm: Single Box 230mmx2440mm	206.2 kg
Single Box 230mmx2440mm: Single Box 231mmx2440mm	15.3 kg
Single Box 230mmx2440mm: Single Box 235mmx2440mm	7.8 kg
Single Box 230mmx2440mm: Single Box 239mmx2440mm	23.5 kg
Single Box 230mmx2440mm: Single Box 241mmx2440mm	15.8 kg
Single Box 230mmx2440mm: Single Box 248mmx2440mm	16.1 kg
Single Box 230mmx2440mm: Single Box 251mmx2440mm	16.3 kg
Single Box 230mmx2440mm: Single Box 255mmx2440mm	16.4 kg
Single Box 230mmx2440mm: Single Box 259mmx2440mm	16.6 kg
Single Box 230mmx2440mm: Single Box 260mmx2440mm	41.7 kg
Single Box 230mmx2440mm: Single Box 270mmx2440mm	8.6 kg
Single Box 230mmx2440mm: Single Box 272mmx2440mm	60.3 kg
Single Box 230mmx2440mm: Single Box 290mmx2440mm	9.0 kg
Single Box 230mmx2440mm: Single Box 320mmx2440mm	263.1 kg
Single Box 230mmx2440mm: Single Box 327mmx2440mm	198.2 kg
Single Box 230mmx2440mm: Single Box 330.2mmx2440mm	69.9 kg
Single Box 230mmx2440mm: Single Box 331mmx2440mm	100.0 kg
Single Box 230mmx2440mm: Single Box 350mmx2440mm	355.2 kg
Single Box 230mmx2440mm: Single Box 355mmx2440mm	31.7 kg
Single Box 230mmx2440mm: Single Box 358mmx2440mm	10.6 kg
Single Box 230mmx2440mm: Single Box 432mmx2440mm	24.7 kg
Single Box 230mmx2440mm: Single Box 80mmx2440mm	12.4 kg
Single End Sheet 120mmx2440mmx12mm: Single End Sheet 120mmx2440mmx12mm	1.4 kg
Window Ope Center 910mm: Window Ope Center 910mm	2,411.9 kg
Window Ope Offset 910mm: Window Ope offset 910mm	1,960.6 kg
Window Ope Offset Half Window: Window Ope Offset Half Window	125.7 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Bamboo plank flooring

Life Cycle Inventory:
90% Bamboo, 10% phenol formaldehyde

Manufacturing Scope:
Cradle to gate for raw material only, includes transportation from China and estimate for material processing neglects materials for installation

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
CN: Bamboo (estimation) PE (2012)
GLO: Bulk commodity carrier PE (2012)
US: Heavy fuel oil at refinery (0.3wt.% S) PE (2010)
CN: Electricity grid mix PE (2010)
DE: Phenol formaldehyde resin PE (2012)

Glazing, triple, insulated (argon), low-E — 9,983.2 kg

Used in the following Revit families:

System Panel: Glazed	9,983.2 kg

Used in the following Tally entries:
Glazing, triple pane IGU

Description:
Glazing, triple, insulated (argon filled), 1/8" float glass, low-E, inclusive of argon gas fill, sealant, and spacers

Life Cycle Inventory:
32.4 kg/m² glass
Argon filled, 0.15 kg/m² low-e coating

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Insulation glass compound (3 panes) PE (2012)

Hardware, stainless steel — 9.7 kg

Used in the following Revit families:

CLT Door Ope 900mm: CLT Door Ope 900mm	1.2 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	0.6 kg
IntSgl (7): 1010 x 2110mm	2.1 kg
IntSgl (7): 810 x 2110mm	3.1 kg
IntSgl (7): 910 x 2110mm	2.7 kg

Used in the following Tally entries:
Stainless steel, hardware

Description:
Finished, cast stainless steel entry applicable for door, window or other accessory hardware

Life Cycle Inventory:
Stainless steel

Manufacturing Scope:
Cradle to gate

End of Life Scope:
98% recovered (product has 58.1% scrap input while remainder is processed and credited as avoided burden)
2% landfilled (inert material)

Entry Source:
RER: Stainless steel Quarto plate (304) Eurofer (2008)
DE: Steel cast part machining PE (2012)
US: Electricity grid mix PE (2010)
RER: Stainless steel flat product (304) - value of scrap Eurofer (2008)

Interior grade plywood, US — 1,023.1 kg

Used in the following Revit families:

Stair	1,023.1 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Plywood, unfinished

Life Cycle Inventory:
33% PNW
67% SE
Plywood
Proxied by exterior grade plywood

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)

None — 0.0 kg

Used in the following Revit families:

Bamboo LVB	0.0 kg
CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel	0.0 kg
CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel	0.0 kg
CLT Corner Panel: CLT Corner Panel Full Height NE-SE	0.0 kg
CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door	0.0 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	0.0 kg
CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1...	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1022mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1058mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1070mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1100mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1123mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1127mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1130mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1145mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1160mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1192mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1219mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1220mmx2440mm	0.0 kg

LCA Metadata (continued)

CLT Full Panel 1220mmx2440mm: CLT Full Panel 1232mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1252mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1274mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1300mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1305mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1340mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1342mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1352mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1367mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1383mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1427mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1435mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1448mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1450mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1455mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 151mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1547mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1578mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1652mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1702mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1738mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1740mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1762mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1764mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1766mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1800mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1850mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1860mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm 2	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1886mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1918mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1932mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1941mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1942mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1944mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1954mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1996mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2038mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2049mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2056mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2062mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2064mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2111mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2196mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2380mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2440mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2492mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2760mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 290mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 350mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 462mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 496mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 538mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 543mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 556mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 559mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 616.2mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 620mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 640mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 670mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 682mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 700mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 710mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 750mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 772mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 830mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 842mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 876.9mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 896mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 930mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 950mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 978mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1220mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1320mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1490mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1530mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1610mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1990mmx732mm	0.0 kg
CLT Timber	0.0 kg

CLT Window Ope Center 910mm: CLT Window Ope Center 910mm	0.0 kg
CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm	0.0 kg
CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus ...	0.0 kg
Corner Balcony Panel SE-NE 732mmx120mm: Corner Balcony Panel SE-NE ...	0.0 kg
Corner Balcony Panel SW-NW 732mm height: Corner Balcony Panel SW-NW...	0.0 kg
Corner Panel NE Corner: Corner Panel NE Corner	0.0 kg
Cross Laminated Timber CLT	0.0 kg
Cross Laminated Timber Mass 100mm	0.0 kg
Cross Laminated Timber Mass 188mm	0.0 kg
Cross Laminated Timber Mass 300	0.0 kg
Door ope Panel 2440mmx1220mm w-900x2110 No Door: Door ope Panel 244...	0.0 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	0.0 kg
Generic Bamboo Mass 100	0.0 kg
Generic Bamboo Mass 188mm	0.0 kg
Generic Bamboo Mass 300	0.0 kg
Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx1...	0.0 kg
Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx7...	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 100mm Width	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 270mm Width	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 310mm Width	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 390mm Width	0.0 kg
IntSgl (7): 1010 x 2110mm	0.0 kg
IntSgl (7): 810 x 2110mm	0.0 kg
IntSgl (7): 910 x 2110mm	0.0 kg
LVB Bamboo Floor	0.0 kg
LVB Panel Full Size: LVB Panel 1000mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1022mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1058mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1070mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1100mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1130mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1145mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1160mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1192mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 520mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 538mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 546mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 554mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 616.2mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 616mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 620mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 630mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 662mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 666mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 670mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 682mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 698mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 710mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 712mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 722mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 724mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 730mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 734mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 750mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 772mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 776mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 803mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 818mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 829mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 830mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 832mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 836mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 842mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 876.9mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 877mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 891mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 900mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 930mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 950mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 976mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 978mm Width	0.0 kg
LVB Panel Full Size: LVB Panel Full Size	0.0 kg
Quad Corner Mullion: Quad Mullion Bamboo	0.0 kg
Rectangular Mullion: 50 x 120mm Bamboo	0.0 kg
Rectangular Mullion: 50 x 150mm Bamboo	0.0 kg
Single Box 230mmx2440mm: Single Box 120mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 122mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 132mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 147mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 151mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 152mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 163.2mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 191mmx2440mm	0.0 kg

LCA Metadata (continued)

Single Box 230mmx2440mm: Single Box 207mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 221mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 223.1mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 228mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 230mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 231mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 235mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 239mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 241mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 248mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 251mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 255mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 259mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 260mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 270mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 272mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 290mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 320mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 327mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 330.2mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 331mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 350mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 355mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 358mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 432mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 80mmx2440mm	0.0 kg
Single End Sheet 120mmx2440mmx12mm: Single End Sheet 120mmx2440mmx12mm	0.0 kg
Stair	0.0 kg
Window Ope Center 910mm: Window Ope Center 910mm	0.0 kg
Window Ope Offset 910mm: Window Ope offset 910mm	0.0 kg
Window Ope Offset Half Window: Window Ope Offset Half Window	0.0 kg

Used in the following Tally entries:
Cross laminated timber (CrossLam / CLT)
Domestic softwood
Door, interior, wood, MDF core, flush
Flooring, bamboo plank
Flooring, engineered wood plank

Description:
This entry is a placeholder, for use in cases when there is "no" finish, or "no added material designated.

Manufacturing Scope:
NA

Entry Source:
None

Paint, interior acrylic latex — 3.4 kg

Used in the following Revit families:

Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	3.4 kg

Used in the following Tally entries:
Domestic softwood

Description:
Application paint emulsion (building, interior, white, wear resistant)

Life Cycle Inventory:
2% organic solvents

Manufacturing Scope:
Cradle to gate, including emissions during application

End of Life Scope:
100% to landfill (plastic waste)

Entry Source:
DE: Application paint emulsion (building, interior, white, wear resistant) PE (2012)

Polyurethane floor finish, water-based — 203.3 kg

Used in the following Revit families:

Stair	203.3 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Water-based polyurethane wood stain, inclusive of catalyst

Life Cycle Inventory:
97.7% stain (50% water, 35% polyurethane dispersions, 5% dipropylene glycol dimethyl ether, 5% tri-butoxyethyl phosphate, 5% dipropylene glycol methyl ether), 2.3% catalyst (75% polyfunctional aziridine, 25% 2-propoxyethanol)
24.5% NMVOC emissions during application

Manufacturing Scope:
Cradle to gate, including emissions during application

End of Life Scope:
26.7% solids to landfill (plastic waste)

Entry Source:
DE: Ethylene glycol butyl ether PE (2012)
US: Epichlorohydrin (by product calcium chloride, hydrochloric acid) PE (2012)
DE: Propylenglycolmonomethylether (Methoxypropanol) PGME PE (2012)
US: Tap water from groundwater PE (2012)
DE: Polyurethane (copolymer-component) (estimation from TPU adhesive) PE (2012)
US: Electricity grid mix PE (2010)

Powder coating, metal stock — 91.0 kg

Used in the following Revit families:

1100mm	72.9 kg
Quad Corner Mullion: Quad Mullion 1	0.5 kg
Rectangular Mullion: 50 x 120mm	1.3 kg
Rectangular Mullion: 50 x 150mm	16.3 kg

Used in the following Tally entries:
Aluminum, extrusion

Description:
Powder coating, for metal stock

Manufacturing Scope:
Cradle to gate, including application

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Application top coat powder (aluminium) PE (2012)
DE: Coating powder (industry
outside
red) PE (2012)

Stainless steel, door hardware, lever lock, interior, residential — 2,302.9 kg

Used in the following Revit families:

CLT Door Ope 900mm: CLT Door Ope 900mm	1,416.3 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	708.2 kg
IntSgl (7): 1010 x 2110mm	48.2 kg
IntSgl (7): 810 x 2110mm	69.5 kg
IntSgl (7): 910 x 2110mm	60.8 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Stainless steel door fitting (hinges and lockset) for use on residential interior door assemblies.

Life Cycle Inventory:
Door hinges 0.622 kg/part, Battalion Lever Lockset, Light Duty, Privacy 0.70 kg/part

Manufacturing Scope:
Cradle to gate, including disposal of packaging.

End of Life Scope:
90% collection rate
remaining 10% deposited in the LCA model without recycling
material recycling efficiency dependant on the metal (89% steel, 90.2% aluminum, stainless steel 83%, zinc 91%, brass 94%)
Plastic components incinerated resulting in credits for electricity and thermal energy

Entry Source:
DE: Fitting stainless steel - FSB (2009)

LCA Metadata (continued)

Veneer, hardwood	307.1 kg
Used in the following Revit families:	
Stair	307.1 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Hardwood veneer

Life Cycle Inventory:
43% PNW
57% SE
veneer

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% landfilled (biodegradable waste)

Entry Source:
US: Dry veneer, at plywood plant, PNW USLCI/PE (2009)
US: Dry veneer, at plywood plant, SE USLCI/PE (2009)

Stadthaus, Murray Grove

Design option comparison Plywood Hybrid / Solid Laminated Bamboo

31/08/2015

Table of Contents

Report Summary

Created with Tally
Non-commercial Version 2014.06.17.01

Author : Philip Kavanagh
Company : Dublin Institute of Technology
Date : 31/08/2015

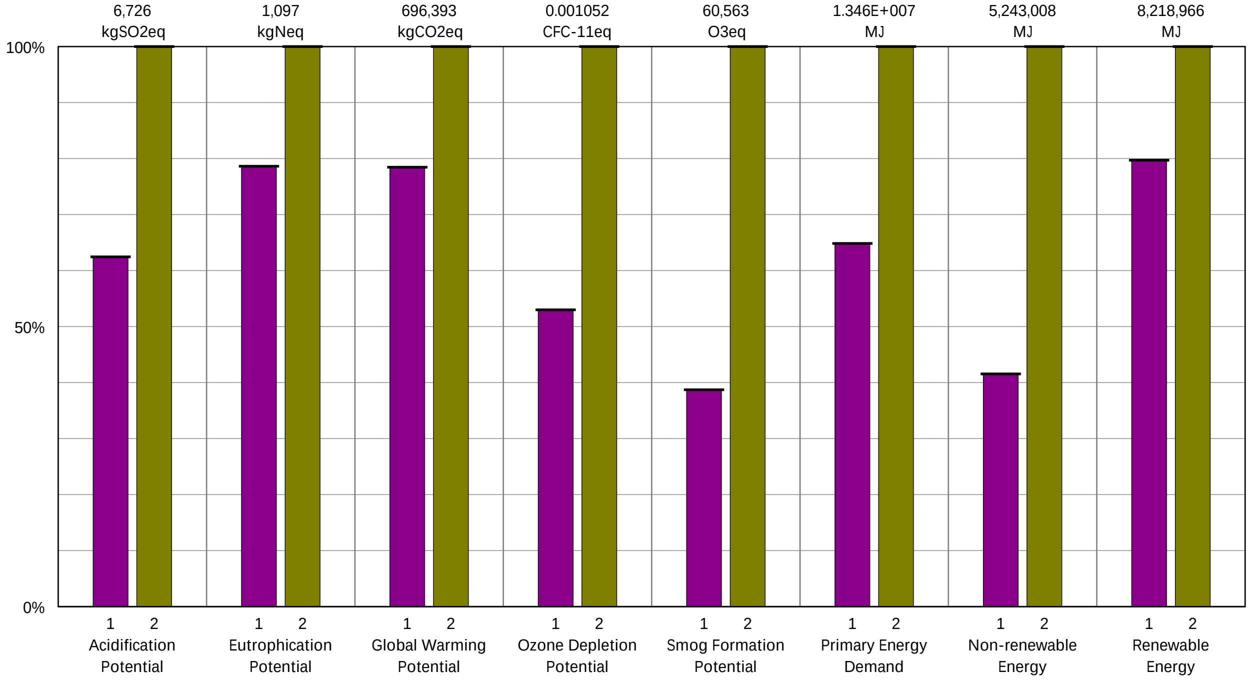
Project : Stadthaus, Murray Grove
Location : Murray Grove, London, England
Gross Area : 2782.998 m²
Building Life : 50

Scope : Cradle-to-Grave, exclusive of operational energy

Goal of Assessment :
Advancing on the scope to determine the global warming potential, through life cycle analysis, of laminated veneer bamboo hybrid construction panels against that of cross laminated timber panels for high rise residential housing.

Object of Study

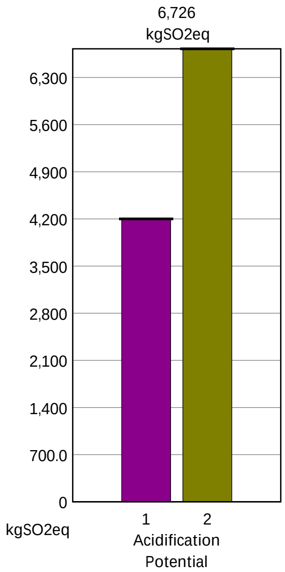
Design options set 'Option Set 1'
Plywood Hybrid Box (primary)
Solid Laminated bamboo

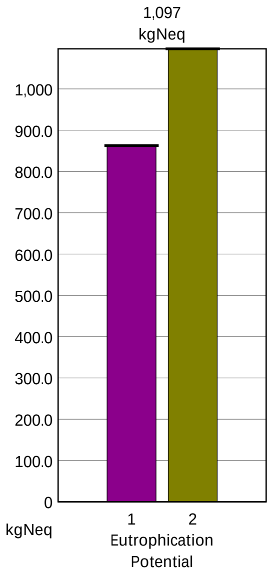


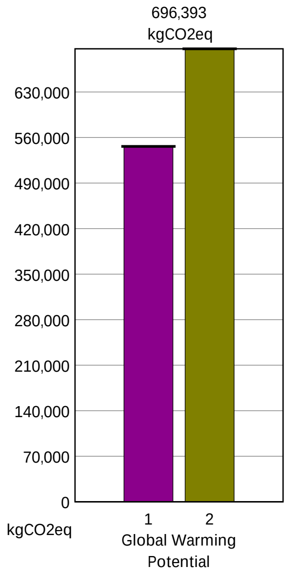
Legend

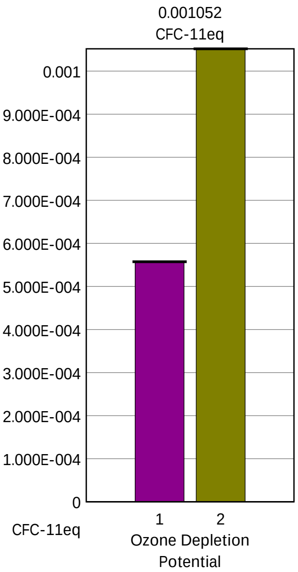
Design Options
Plywood Hybrid Box (primary)
Solid Laminated bamboo

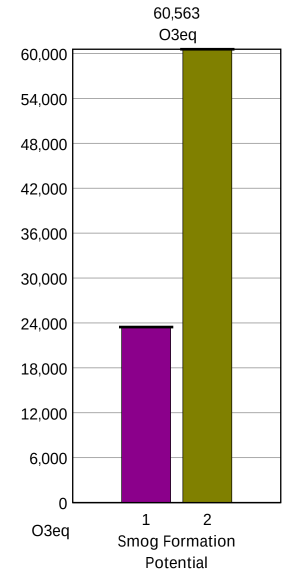
Report Summary (continued)

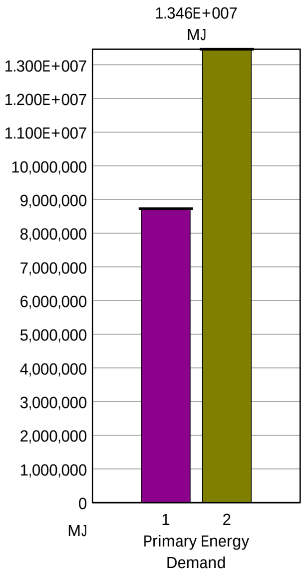


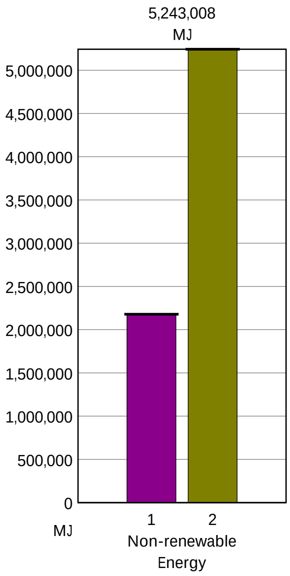


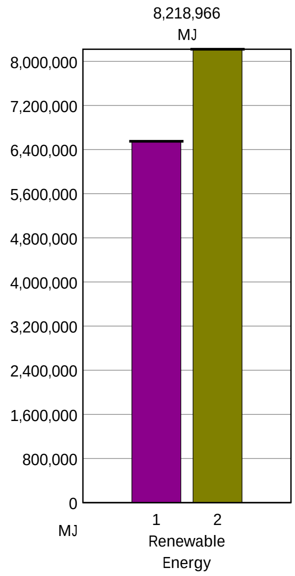










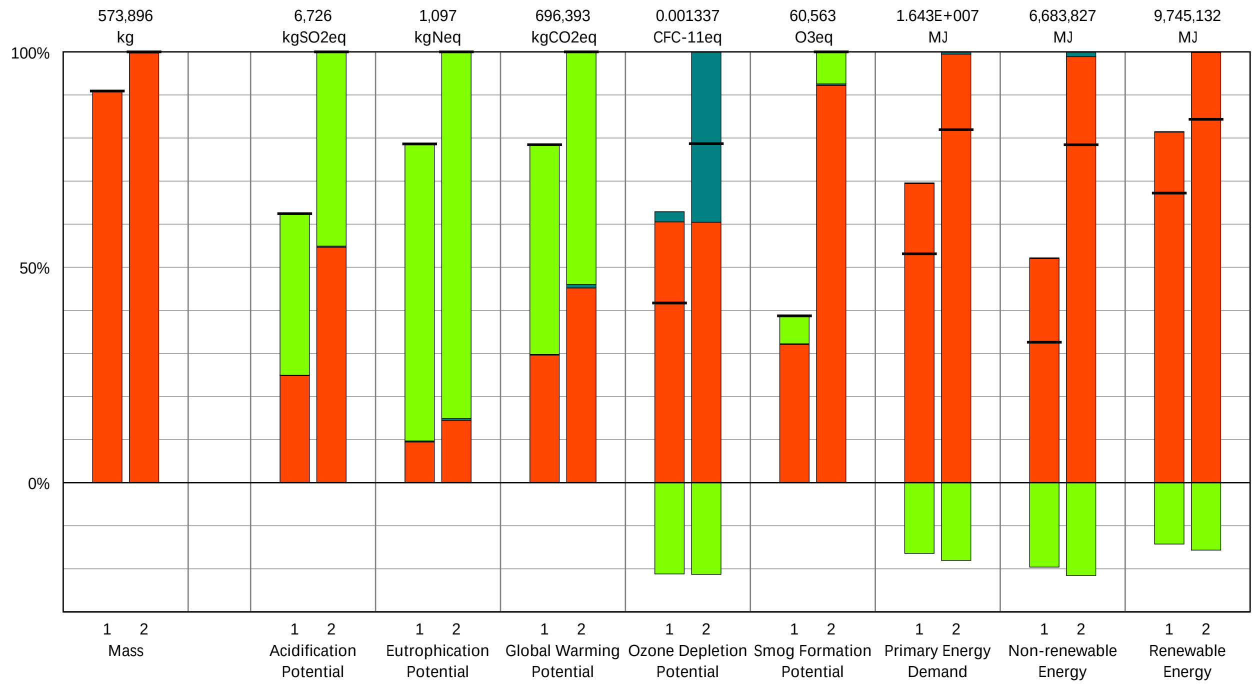


Legend

Design Options

- Plywood Hybrid Box (primary)
- Solid Laminated bamboo

Results per Life Cycle Stage



Legend

Net value (impacts + credits)

Design Options

Option 1 - Plywood Hybrid Box (primary)

Option 2 - Solid Laminated bamboo

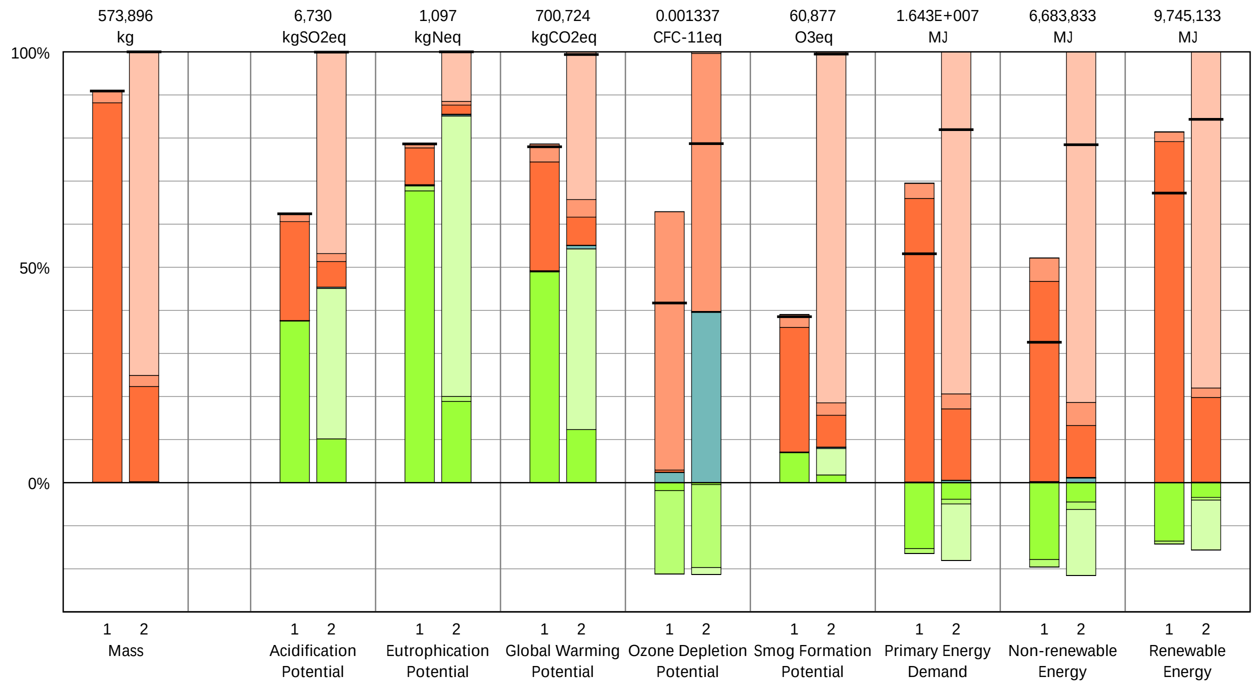
Life Cycle Stages

Manufacturing

Maintenance and Replacement

End of Life

Results per Life Cycle Stage, itemized by CSI Division



Legend

Net value (impacts + credits)

Design Options

Option 1 - Plywood Hybrid Box (primary)

Option 2 - Solid Laminated bamboo

Manufacturing

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

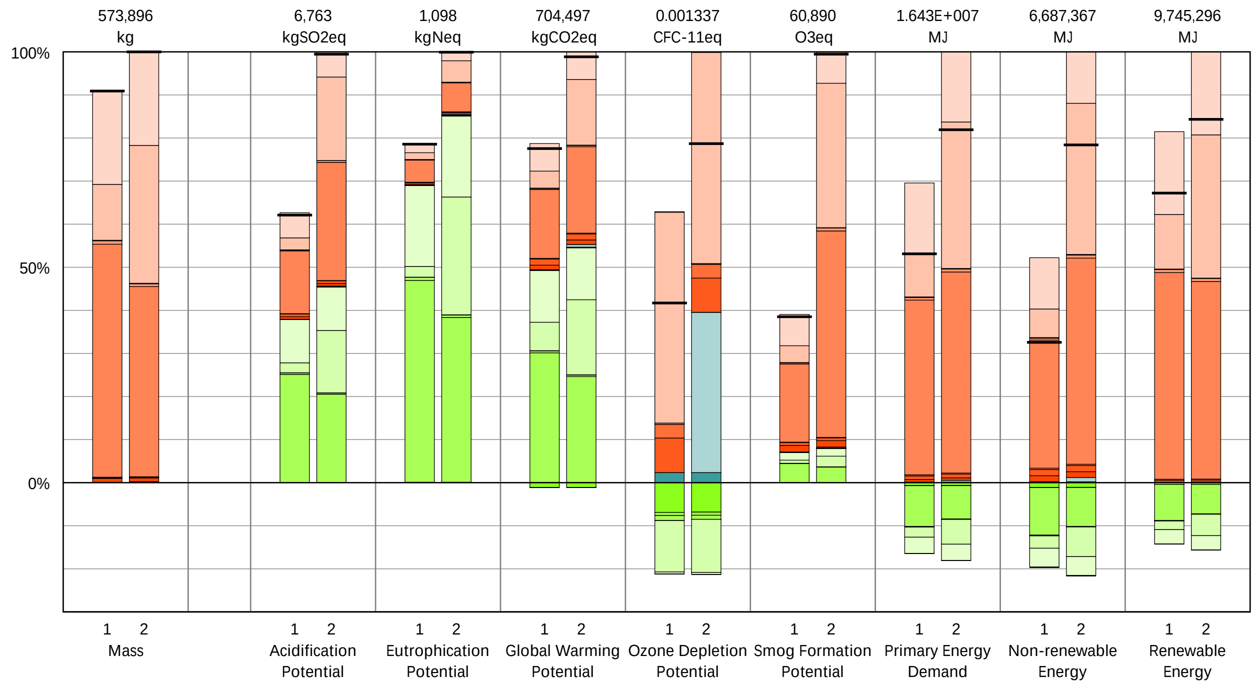
Maintenance and Replacement

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

End of Life

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

Results per Life Cycle Stage, itemized by Revit Category



Legend

Net value (impacts + credits)

Design Options

Option 1 - Plywood Hybrid Box (primary)

Option 2 - Solid Laminated bamboo

Manufacturing

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

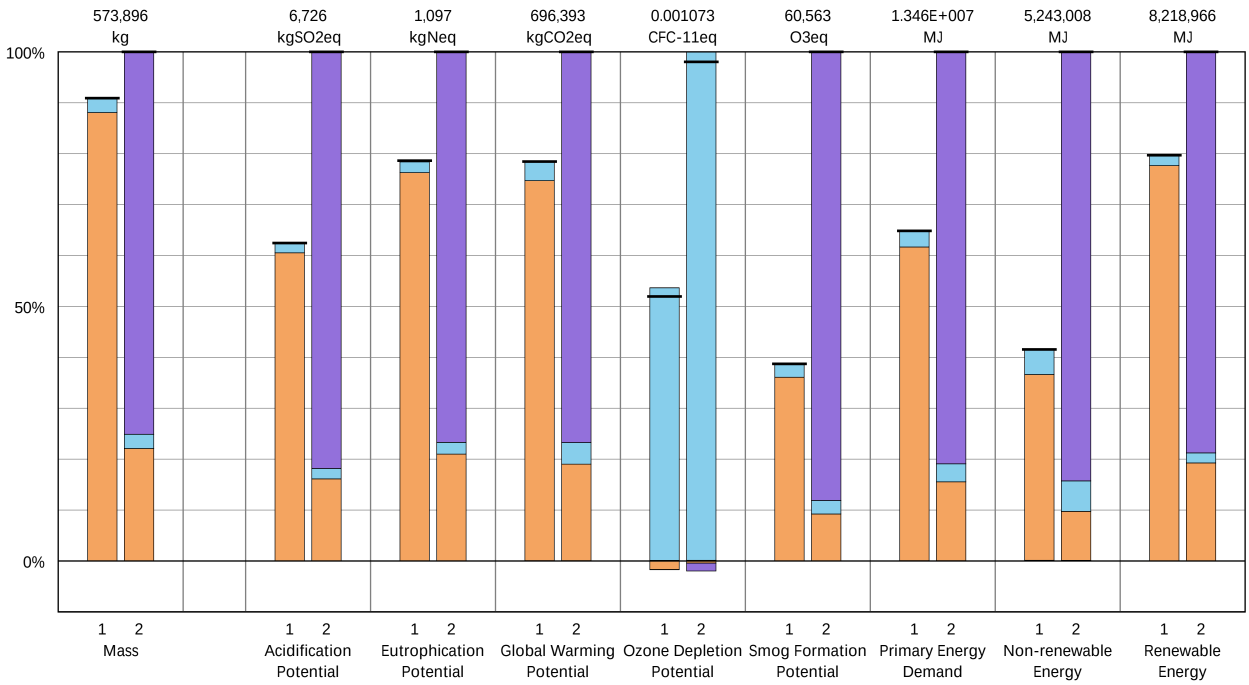
Maintenance and Replacement

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

End of Life

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per CSI Division



Legend

Design Options

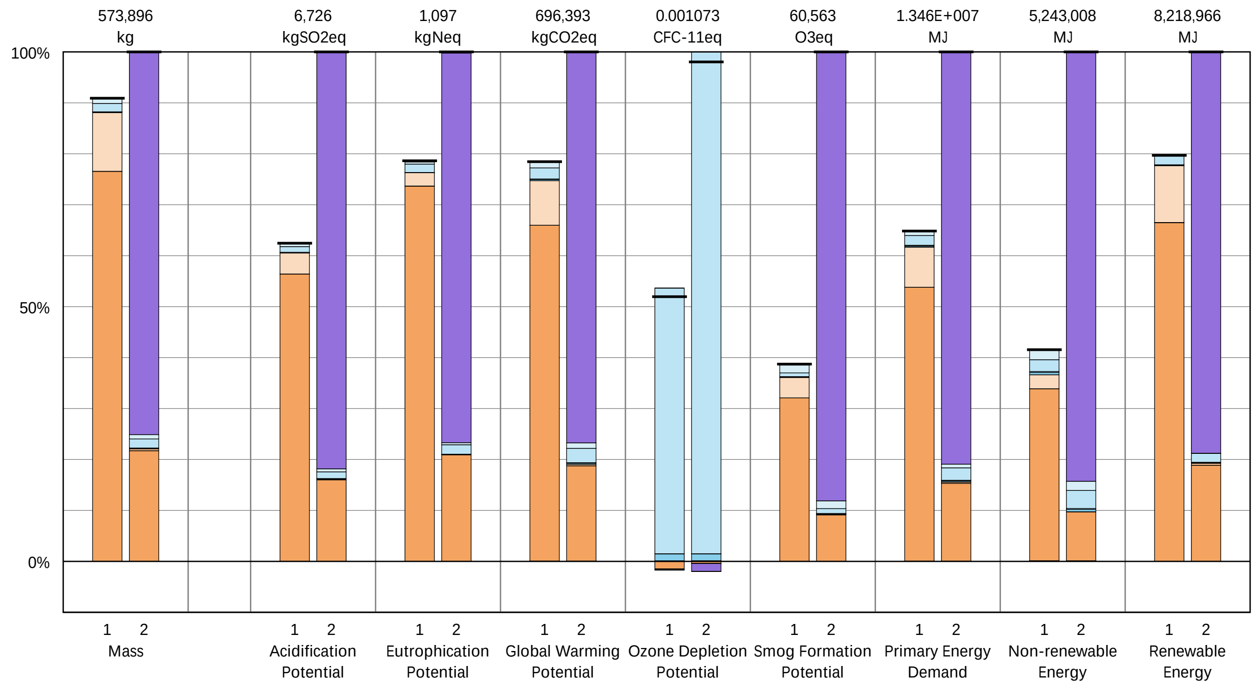
Option 1 - Plywood Hybrid Box (primary)

Option 2 - Solid Laminated bamboo

CSI Divisions

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

Results per CSI Division, itemized by Tally Entry



Legend

Design Options

Option 1 - Plywood Hybrid Box (primary)

Option 2 - Solid Laminated bamboo

05 - Metals

- Aluminum, extrusion
- Stainless steel, hardware

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam / CLT)
- Domestic softwood
- Plywood, exterior grade

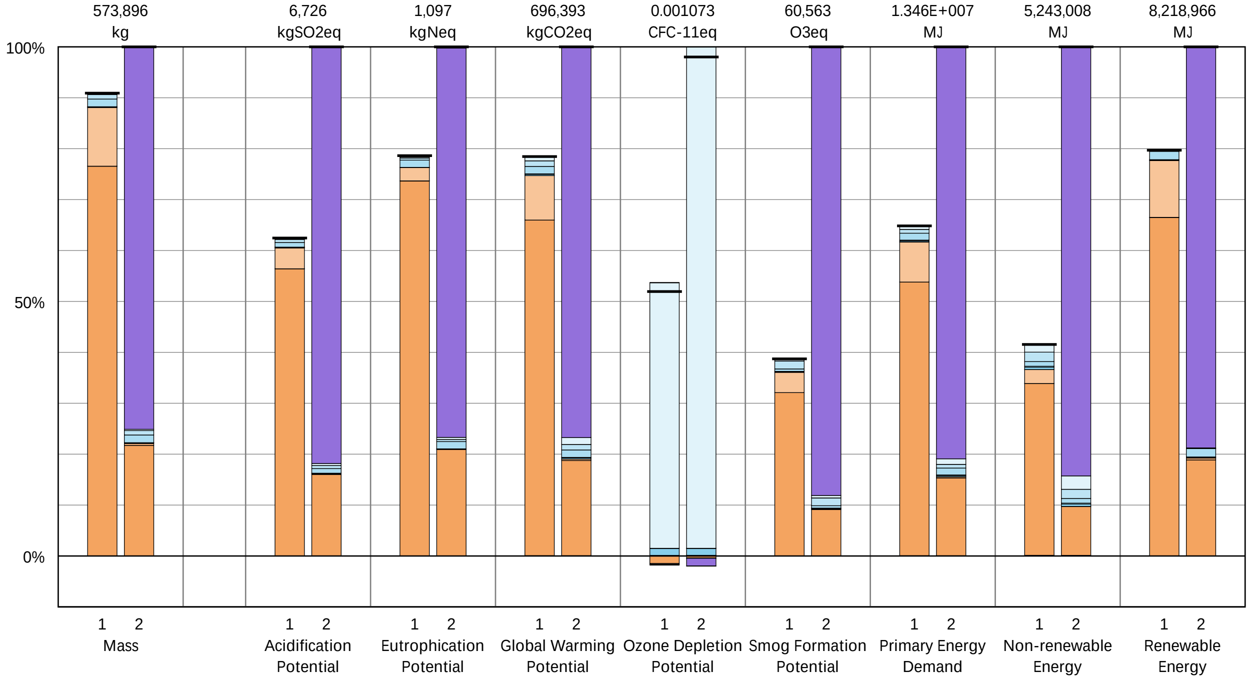
08 - Openings and Glazing

- Aluminum mullion
- Door frame, wood
- Door, interior, wood, MDF core, flush
- Glazing, triple pane IGU

09 - Finishes

- Flooring, bamboo plank
- Flooring, engineered wood plank

Results per CSI Division, itemized by Material



Legend

Design Options

Option 1 - Plywood Hybrid Box (primary)

Option 2 - Solid Laminated bamboo

05 - Metals

- Aluminum, extruded
- Hardware, stainless steel
- Powder coating, metal stock

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam)
- Domestic softwood, US
- Exterior grade plywood, US
- None
- Paint, interior acrylic latex

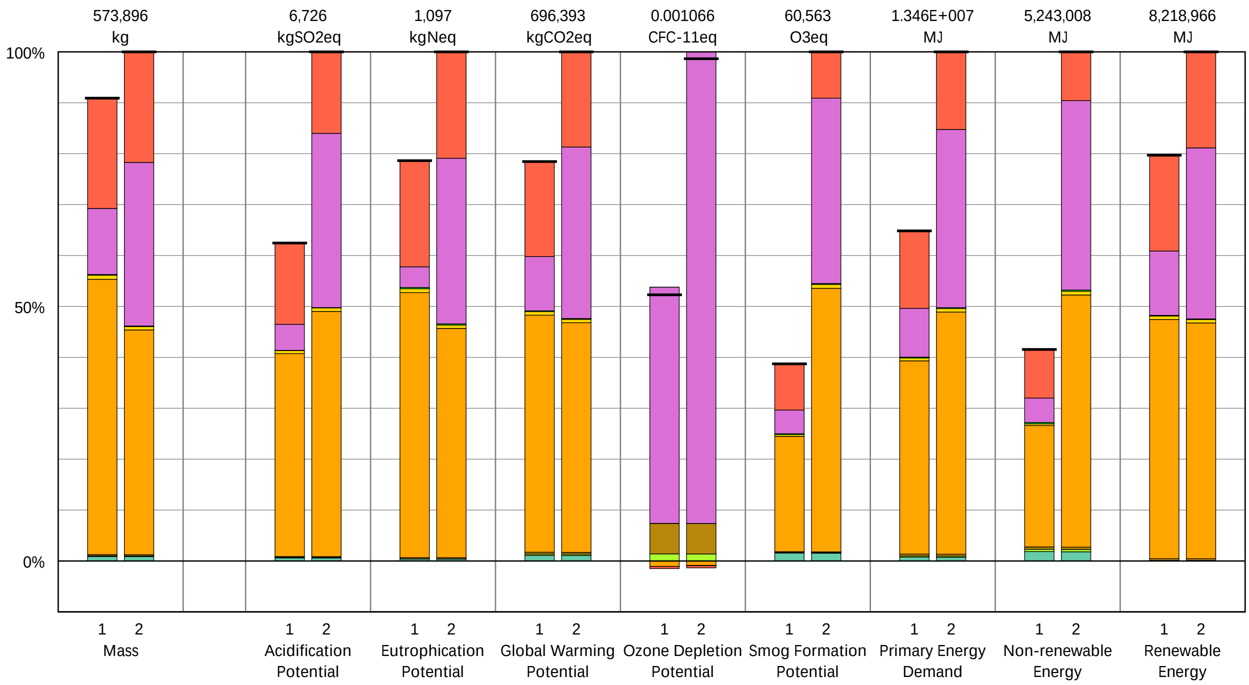
08 - Openings and Glazing

- Aluminum, extruded
- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Glazing, triple, insulated (argon), low-E
- None
- Stainless steel, door hardware, lever lock, interior, residential

09 - Finishes

- Flooring, bamboo plank
- Interior grade plywood, US
- None
- Polyurethane floor finish, water-based
- Veneer, hardwood

Results per Revit Category



Legend

Design Options

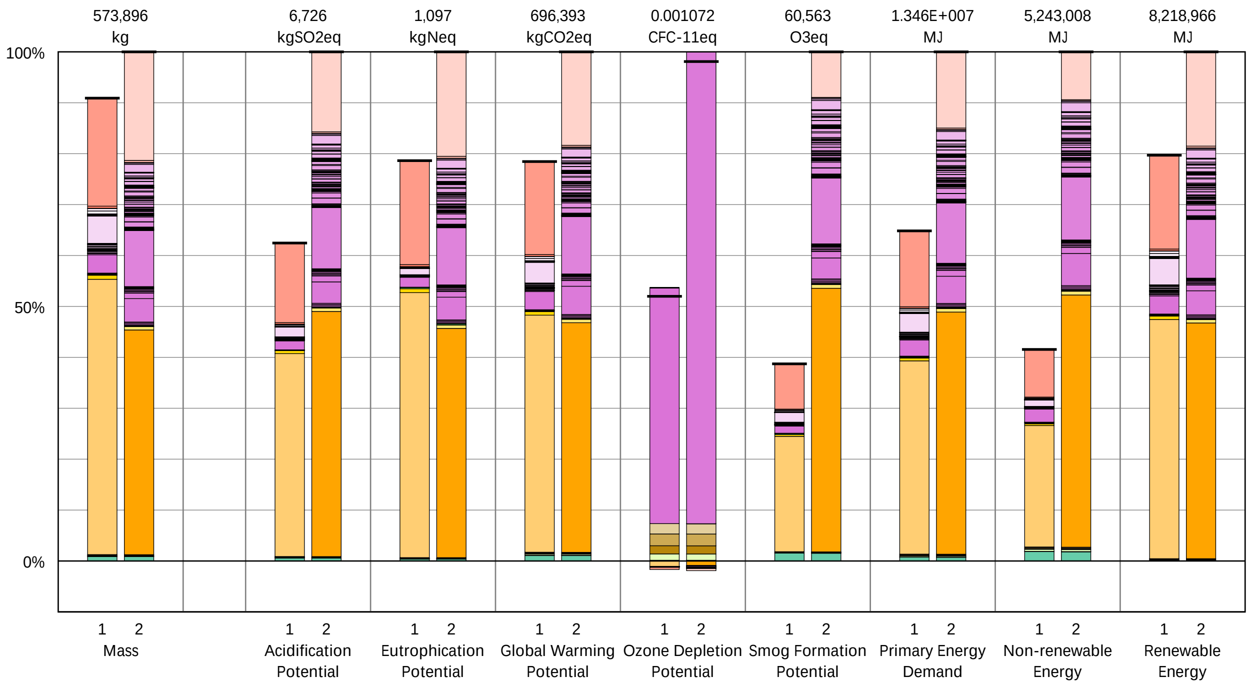
Option 1 - Plywood Hybrid Box (primary)

Option 2 - Solid Laminated bamboo

Revit Categories

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per Revit Category, itemized by Family



Legend

Design Options

Option 1 - Plywood Hybrid Box (primary)
Option 2 - Solid Laminated bamboo

Curtain Panels

- System Panel: Glazed

Curtain Wall Mullions

- Quad Corner Mullion: Quad Mullion 1
- Rectangular Mullion: 50 x 120mm
- Rectangular Mullion: 50 x 120mm Bamboo
- Rectangular Mullion: 50 x 150mm

Doors

- IntSgl (7): 1010 x 2110mm
- IntSgl (7): 810 x 2110mm
- IntSgl (7): 910 x 2110mm

Floors

- CLT Timber
- LVB Bamboo Floor

Roofs

- Bamboo LVB
- Cross Laminated Timber CLT

Stairs and Railings

- 1100mm
- Stair

Structure

- Corner Balcony Panel SE-NE 732mmx120mm: Corner Balcony Panel SE-NE 732mmx12…
- Corner Balcony Panel SW-NW 732mm height: Corner Balcony Panel SW-NW 732mm h…
- Corner Panel NE Corner: Corner Panel NE Corner
- Door ope Panel 2440mmx1220mm w-900x2110 No Door: Door ope Panel 2440mmx12…m…
- Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx1220m…9…
- Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx1220mm
- Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx770mm
- Half Panel Single 230mm Width: Half Panel Single 100mm Width
- Half Panel Single 230mm Width: Half Panel Single 270mm Width
- Half Panel Single 230mm Width: Half Panel Single 310mm Width
- Half Panel Single 230mm Width: Half Panel Single 390mm Width
- Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NE-SE Corner Panel
- Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NW-SW Corner Panel
- Mass Bamboo Corner Panel: Mass Bamboo Corner Panel Full Height NE-SE
- Mass Bamboo Door Ope 900mm No Door: Mass Bamboo Door Ope 900mm No Door
- Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm
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- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1058mmx2440mm
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- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1740mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1762mmx2440mm

Results per Revit Category, itemized by Family (continued)

Legend (continued)

- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1764mmx2440m
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1766mmx2440m
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1800mmx2440m
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- Mass Bamboo Window Ope Single Plus Half 1260mm: Mass Bamboo Window Ope Sin
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- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1058mm Width
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- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 616.2mm Width
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- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 666mm Width
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- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 722mm Width
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- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 730mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 734mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 750mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 772mm Width
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- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 830mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 832mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 836mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 842mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 876.9mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 877mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 891mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 900mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 930mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 950mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 976mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 978mm Width
- Plywood Hybrid Panel Full Size: Plywood Hybrid Panel Full Size
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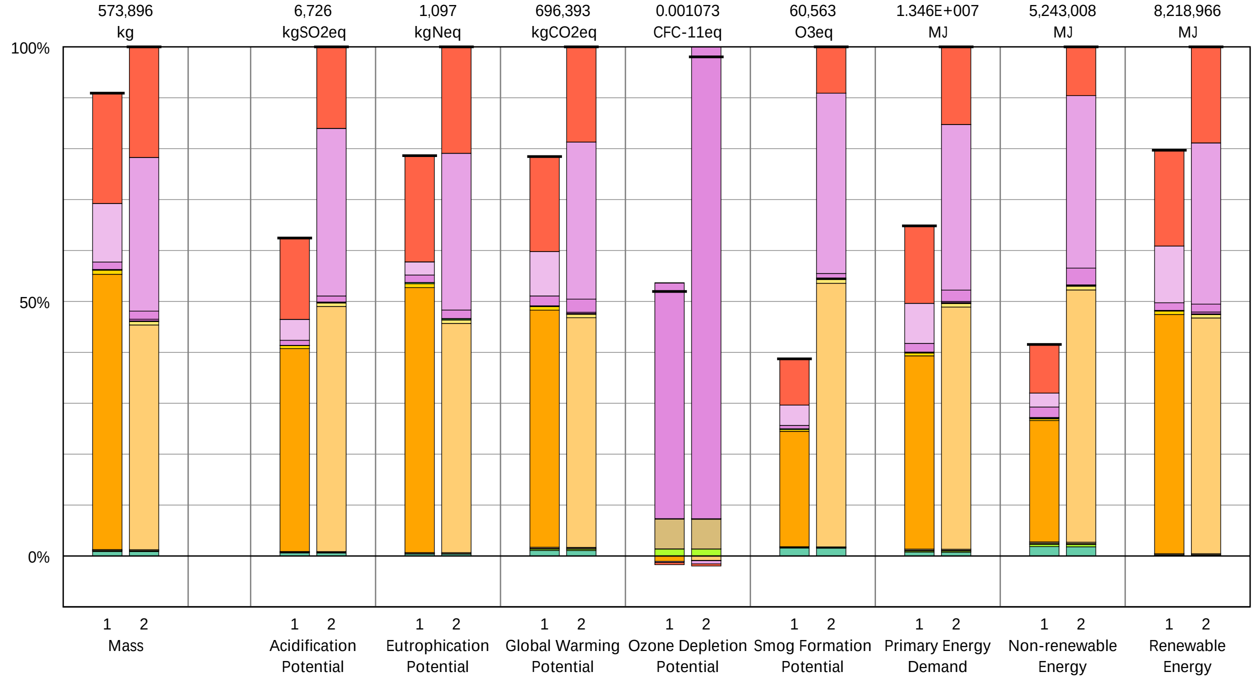
- Single Box 230mmx2440mm: Single Box 122mmx2440mm
- Single Box 230mmx2440mm: Single Box 132mmx2440mm
- Single Box 230mmx2440mm: Single Box 147mmx2440mm
- Single Box 230mmx2440mm: Single Box 151mmx2440mm
- Single Box 230mmx2440mm: Single Box 152mmx2440mm
- Single Box 230mmx2440mm: Single Box 163.2mmx2440mm
- Single Box 230mmx2440mm: Single Box 191mmx2440mm
- Single Box 230mmx2440mm: Single Box 207mmx2440mm
- Single Box 230mmx2440mm: Single Box 221mmx2440mm
- Single Box 230mmx2440mm: Single Box 223.1mmx2440mm
- Single Box 230mmx2440mm: Single Box 228mmx2440mm
- Single Box 230mmx2440mm: Single Box 230mmx2440mm
- Single Box 230mmx2440mm: Single Box 231mmx2440mm
- Single Box 230mmx2440mm: Single Box 235mmx2440mm
- Single Box 230mmx2440mm: Single Box 239mmx2440mm
- Single Box 230mmx2440mm: Single Box 241mmx2440mm
- Single Box 230mmx2440mm: Single Box 248mmx2440mm
- Single Box 230mmx2440mm: Single Box 251mmx2440mm
- Single Box 230mmx2440mm: Single Box 255mmx2440mm
- Single Box 230mmx2440mm: Single Box 259mmx2440mm
- Single Box 230mmx2440mm: Single Box 260mmx2440mm
- Single Box 230mmx2440mm: Single Box 270mmx2440mm
- Single Box 230mmx2440mm: Single Box 272mmx2440mm
- Single Box 230mmx2440mm: Single Box 290mmx2440mm
- Single Box 230mmx2440mm: Single Box 320mmx2440mm
- Single Box 230mmx2440mm: Single Box 327mmx2440mm
- Single Box 230mmx2440mm: Single Box 330.2mmx2440mm
- Single Box 230mmx2440mm: Single Box 331mmx2440mm
- Single Box 230mmx2440mm: Single Box 350mmx2440mm
- Single Box 230mmx2440mm: Single Box 355mmx2440mm
- Single Box 230mmx2440mm: Single Box 358mmx2440mm
- Single Box 230mmx2440mm: Single Box 432mmx2440mm
- Single Box 230mmx2440mm: Single Box 80mmx2440mm
- Single End Sheet 120mmx2440mmx12mm: Single End Sheet 120mmx2440mmx12mm
- Window Ope Center 910mm: Window Ope Center 910mm
- Window Ope Offset 910mm: Window Ope offset 910mm
- Window Ope Offset Half Window: Window Ope Offset Half Window

Walls

- Cross Laminated Timber Mass 100mm
- Cross Laminated Timber Mass 188mm
- Cross Laminated Timber Mass 300
- Generic Bamboo Mass 188mm
- Generic Bamboo Mass 300

Results per Revit Category, itemized by Tally Entry



Legend

Design Options

Option 1 - Plywood Hybrid Box (primary)

Option 2 - Solid Laminated bamboo

Curtain Panels

Glazing, triple pane IGU

Curtain Wall Mullions

Aluminum mullion

Doors

Domestic softwood

Door frame, wood

Door, interior, wood, MDF core, flush

Stainless steel, hardware

Floors

Cross laminated timber (CrossLam / CLT)

Flooring, bamboo plank

Roofs

Cross laminated timber (CrossLam / CLT)

Flooring, bamboo plank

Stairs and Railings

Aluminum, extrusion

Flooring, engineered wood plank

Structure

Domestic softwood

Door, interior, wood, MDF core, flush

Flooring, bamboo plank

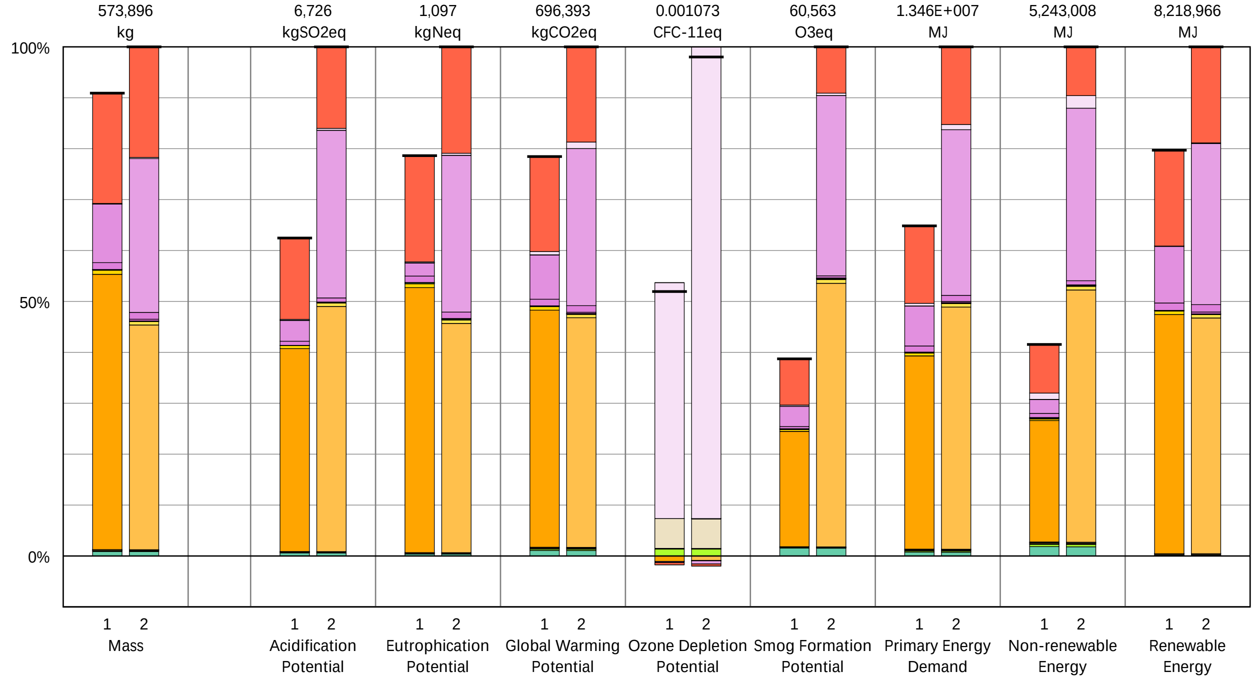
Plywood, exterior grade

Stainless steel, hardware

Walls

Cross laminated timber (CrossLam / CLT)

Results per Revit Category, itemized by Material



Legend

Design Options
Option 1 - Plywood Hybrid Box (primary)
Option 2 - Solid Laminated bamboo

Curtain Panels
Glazing, triple, insulated (argon), low-E

Curtain Wall Mullions
Aluminum, extruded
None

Doors
Domestic softwood, US
Door frame, wood, no door
Door, interior, wood, MDF Core, flush
Hardware, stainless steel
None
Stainless steel, door hardware, lever lock, interior, residential

Floors
Cross laminated timber (CrossLam)
Flooring, bamboo plank
None

Roofs
Cross laminated timber (CrossLam)
Flooring, bamboo plank
None

Stairs and Railings
Aluminum, extruded
Interior grade plywood, US
None
Polyurethane floor finish, water-based
Powder coating, metal stock
Veneer, hardwood

Structure
Domestic softwood, US
Door, interior, wood, MDF Core, flush
Exterior grade plywood, US
Flooring, bamboo plank
Hardware, stainless steel
None
Paint, interior acrylic latex
Stainless steel, door hardware, lever lock, interior, residential

Walls
Cross laminated timber (CrossLam)
None

Calculation Methodology

Studied objects

The LCA results in the report represent either an analysis of a single building, or a comparative analysis of two or more building design options. The single building may represent the complete architectural, structural, and finish systems of a building or a subset of those systems, and it may be used to compare the relative contributions of building systems to environmental impacts and for comparative study with one or more reference buildings. The comparison of design options may represent a full building in various stages of the design process, or they may represent multiple schemes of a full or partial building that are being compared to one another across a range of evaluation criteria.

Functional unit and reference flow

The functional unit of the analysis is the usable floor space of the building under study. For a design option comparison of a partial building, the functional unit is the complete set of building systems that performs a given function. The reference flow is the amount of material required to produce a building, or portion thereof, designed according to the given goal and scope of the assessment, over the full life of the building. If operational energy is included in the assessment the reference flow also includes the electrical and thermal energy consumed on site over the life of the building. It is the responsibility of the modeler to assure that reference buildings or design options are functionally equivalent in terms of scope, size, and relevant performance. The expected life of the building has a default value of 60 years and can be modified by the model author.

System boundaries and delimitations

The analysis accounts for the full cradle-to-grave life cycle of the design options studied, including material manufacturing, maintenance and replacement, and eventual end-of-life (disposal, incineration, and/or recycling), including the materials and energy used across all life cycle stages. Optionally, the operational energy of the building can be included within the scope.

Architectural materials and assemblies include all materials required for the product’s manufacturing and use (including hardware, sealants, adhesives, coatings, and finishing, etc.) up to a 1% cut-off factor by mass with the exception of known materials that have high environmental impacts at low levels. In these cases, a 1% cut-off was implemented by impact.

Manufacturing includes cradle-to-gate manufacturing wherever possible. This includes raw material extraction and processing, intermediate transportation, and final manufacturing and assembly. Due to data limitations, however, some manufacturing steps have been excluded, such as the material and energy requirements for assembling doors and windows. The manufacturing scope is listed for each entry, detailing any specific inclusions or exclusions that fall outside of the cradle-to-gate scope.

Transportation of upstream raw materials or intermediate products to final manufacturing is generally included in the GaBi datasets utilized within this tool. Transportation requirements between the manufacturer and installation of the product, and at the end-of-life of the product, are excluded from this study.

Infrastructure (buildings and machinery) required for the manufacturing and assembly of building materials, as well as packaging materials, are not included and are considered outside the scope of assessment.

Maintenance and replacement encompasses the replacement of materials in accordance with the expected service life. This includes the end-of-life treatment of the existing products and cradle-to-gate manufacturing of the replacement products. The service life is specified separately for each product.

Operational energy treatment is based on the anticipated energy consumed at the building site over the lifetime of the building. Each energy dataset includes relevant upstream impacts associated with extraction of energy resources (e.g., coal, crude oil), refining, combustion, transmission, losses, and other associated factors. US electricity generation datasets are based on subregions from US EPA's eGRID2012 database v1.0, but adapted to account for imports and exports into these regions. These consumption mixes - unique to the GaBi databases - provide a more accurate reflection of impacts associated with electricity consumption.

End-of-life treatment is based on average US construction and demolition waste treatment methods and rates. This includes the relevant material collection rates for recycling, processing requirements for recycled materials, incineration rates, and landfilling rates. Along with processing requirements, the recycling of materials is modeled using an avoided burden approach, where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material. Incineration of materials includes credit for average US energy recovery rates. The impacts associated with landfilling are based on average material properties, such as plastic waste, biodegradable waste, or inert material. Specific end-of-life scenarios are detailed for each entry.

Data source and quality

Tally utilizes a custom designed LCA database that combines material attributes, assembly details, and engineering and architectural specifications with environmental impact data resulting from the collaboration between KieranTimberlake and PE INTERNATIONAL. LCA modeling was conducted in GaBi 6 using GaBi databases and in accordance with GaBi database and modeling principles.

Geography and date: The data used are intended to represent the US and the year 2013. Where representative data were unavailable, proxy data were used. The datasets used, their geographic region, and year of reference are listed for each entry. An effort was made to choose proxy datasets that are technologically consistent with the relevant entry.

Uncertainty in results can stem from both the data used and the application of the data. Data quality is judged by its precision (measured, calculated, or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological). The LCI data sets from the GaBi LCI databases have been used in LCA models worldwide in industrial and scientific applications, both as internal and critically reviewed and published studies. The uncertainty introduced by the use of any proxy data is reduced by using technologically, geographically, and/or temporally similar data. It is the responsibility of the modeler to apply the predefined material entries appropriately to the building under study.

Tally methodology is consistent with LCA standards ISO 14040-14044.

Glossary of LCA Terminology

Environmental Impact Categories

The following list provides a description of environmental impact categories reported according to the TRACI 2.1 characterization scheme. References: [Bare 2010, EPA 2012, Guinée 2001]

Acidification Potential (AP) — kg SO2 eq

A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline, and the deterioration of building materials.

Eutrophication Potential (EP) — kg N eq

Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.

Global Warming Potential (GWP) — kg CO2 eq

A measure of greenhouse gas emissions, such as CO2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health, and material welfare.

Ozone Depletion Potential (ODP) — kg CFC-11 eq

A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants.

Smog Formation Potential (SFP) — kg O3 eq

Ground level ozone is created by various chemical reactions, which occur between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in sunlight. Human health effects can result in a variety of respiratory issues including increasing symptoms of bronchitis, asthma, and emphysema. Permanent lung damage may result from prolonged exposure to ozone. Ecological impacts include damage to various ecosystems and crop damage. The primary sources of ozone precursors are motor vehicles, electric power utilities, and industrial facilities.

Primary Energy Demand (PED) — MJ (lower heating value)

A measure of the total amount of primary energy extracted from the earth. PED is expressed in energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.) and energy demand from renewable resources (e.g. hydropower, wind energy, solar, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account.

LCA Metadata

NOTES

The following list provides a summary of all materials and energy inputs present in the selected study. Materials are listed in alphabetical order along with a list of all Revit families and Tally entries in which they occur and any notes and system boundaries accompanying their database entries. The mass given here refers to the full life-cycle mass of material, including manufacturing and replacement.

Aluminum, extruded — 1,638.8 kg

Used in the following Revit families:

1100mm	0.0 kg
Quad Corner Mullion: Quad Mullion 1	28.8 kg
Rectangular Mullion: 50 x 120mm	66.7 kg
Rectangular Mullion: 50 x 120mm Bamboo	66.7 kg
Rectangular Mullion: 50 x 150mm	1,476.8 kg

Used in the following Tally entries:
Aluminum mullion
Aluminum, extrusion

Description:
Extruded aluminum part

Life Cycle Inventory:
Aluminum, process energy

Manufacturing Scope:
Cradle to gate

End of Life Scope:
95% recovered (includes recycling, scrap preparation, and avoided burden credit)
5% landfilled (inert material)

Entry Source:
NA: Primary Aluminium Ingot AA (2011)
EU-27: Aluminium extrusion profile PE (2012)

Cross laminated timber (CrossLam) — 563,833.6 kg

Used in the following Revit families:

Bamboo LVB	4,582.3 kg
Cross Laminated Timber Mass 100mm	246.3 kg
Cross Laminated Timber Mass 188mm	2,341.2 kg
Cross Laminated Timber Mass 300	121,744.4 kg
Generic Bamboo Mass 188mm	2,306.6 kg
Generic Bamboo Mass 300	122,305.1 kg
LVB Bamboo Floor	310,307.9 kg

Used in the following Tally entries:
Cross laminated timber (CrossLam / CLT)

Description:
PROXIED by LVL

Life Cycle Inventory:
43% PNW
57% SE
Proxied by LVL

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
US: Laminated veneer lumber, at plant, US PNW USLCI/PE (2009)
US: Laminated veneer lumber, at plant, US SE USLCI/PE (2009)

Domestic softwood, US — 2,279.0 kg

Used in the following Revit families:

Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	0.0 kg
IntSgl (7): 1010 x 2110mm	74.4 kg
IntSgl (7): 810 x 2110mm	128.8 kg
IntSgl (7): 910 x 2110mm	102.2 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	1,973.6 kg

Used in the following Tally entries:
Domestic softwood

Description:
Dimensional lumber, sawn, planed, dried and cut for standard framing or planking

Life Cycle Inventory:
38% PNW
62% SE
Dimensional lumber

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Surfaced dried lumber, at planer mill, PNW USLCI/PE (2009)
US: Surfaced dried lumber, at planer mill, SE USLCI/PE (2009)

Door frame, wood, no door — 279.1 kg

Used in the following Revit families:

IntSgl (7): 1010 x 2110mm	68.0 kg
IntSgl (7): 810 x 2110mm	117.7 kg
IntSgl (7): 910 x 2110mm	93.4 kg

Used in the following Tally entries:
Door frame, wood

Description:
Wood door frame

Life Cycle Inventory:
Dimensional lumber

Manufacturing Scope:
Cradle to gate, excludes hardware, jamnb, casing, sealant

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
DE: Wooden frame (EN15804 A1-A3) PE (2012)

Door, interior, wood, MDF Core, flush — 17,316.4 kg

Used in the following Revit families:

Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	7,689.4 kg
IntSgl (7): 1010 x 2110mm	523.0 kg
IntSgl (7): 810 x 2110mm	754.9 kg
IntSgl (7): 910 x 2110mm	659.7 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	7,689.4 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Interior flush wood door with MDF core

Life Cycle Inventory:
12.2 kg/m² Wood, 0.052 m3/m3 MDF

Manufacturing Scope:
Cradle to gate, excludes assembly, frame, hardware, and adhesives

End of Life Scope:
14.5% wood products recovered (credited as avoided burden)
22% wood products incinerated with energy recovery
63.5% wood products landfilled (wood product waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)
DE: Wood fibre board PE (2012)

LCA Metadata (continued)

Exterior grade plywood, US	66,036.3 kg
Used in the following Revit families:	
Corner Balcony Panel SE-NE 732mmx120mm: Corner Balcony Panel SE-NE ...	259.3 kg
Corner Balcony Panel SW-NW 732mm height: Corner Balcony Panel SW-NW...	421.8 kg
Corner Panel NE Corner: Corner Panel NE Corner	441.2 kg
Door ope Panel 2440mmx1220mm w-900x2110 No Door: Door ope Panel 244...	462.3 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	12,242.3 kg
Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx1...	1,406.6 kg
Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx7...	10.3 kg
Half Panel Single 230mm Width: Half Panel Single 100mm Width	2.0 kg
Half Panel Single 230mm Width: Half Panel Single 270mm Width	29.8 kg
Half Panel Single 230mm Width: Half Panel Single 310mm Width	4.1 kg
Half Panel Single 230mm Width: Half Panel Single 390mm Width	34.8 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1000mm Width	118.9 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1022mm Width	443.9 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1058mm Width	83.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1070mm Width	41.9 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1100mm Width	1,285.3 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1130mm Width	175.2 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1145mm Width	177.1 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1160mm Width	895.3 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1192mm Width	183.1 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 520mm Width	23.7 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid panel 538mm Width	24.9 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 546mm Width	25.1 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 554mm Width	50.8 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 616.2mm Width	273.8 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 616mm Width	27.4 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 620mm Width	27.5 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 630mm Width	222.5 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 662mm Width	57.7 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 666mm Width	86.9 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 670mm Width	116.4 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 682mm Width	59.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 698mm Width	209.9 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 710mm Width	151.9 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 712mm Width	30.4 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 722mm Width	461.4 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 724mm Width	61.6 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 730mm Width	31.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 734mm Width	311.4 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 750mm Width	1,424.4 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 772mm Width	226.5 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 776mm Width	194.9 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 803mm Width	100.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 818mm Width	203.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 829mm Width	102.5 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 830mm Width	1,539.5 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 832mm Width	274.2 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 836mm Width	137.6 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 842mm Width	484.3 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 876.9mm Width	71.4 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 877mm Width	35.7 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 891mm Width	72.3 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 900mm Width	72.9 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 930mm Width	112.2 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 950mm Width	608.8 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 976mm Width	38.9 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 978mm Width	38.9 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel Full Size	30,856.6 kg
Single Box 230mmx2440mm: Single Box 120mmx2440mm	20.7 kg
Single Box 230mmx2440mm: Single Box 122mmx2440mm	7.0 kg
Single Box 230mmx2440mm: Single Box 132mmx2440mm	14.6 kg
Single Box 230mmx2440mm: Single Box 147mmx2440mm	7.8 kg
Single Box 230mmx2440mm: Single Box 151mmx2440mm	31.6 kg
Single Box 230mmx2440mm: Single Box 152mmx2440mm	7.9 kg
Single Box 230mmx2440mm: Single Box 163.2mmx2440mm	24.9 kg
Single Box 230mmx2440mm: Single Box 191mmx2440mm	9.2 kg
Single Box 230mmx2440mm: Single Box 207mmx2440mm	48.4 kg
Single Box 230mmx2440mm: Single Box 221mmx2440mm	20.3 kg
Single Box 230mmx2440mm: Single Box 223.1mmx2440mm	40.8 kg
Single Box 230mmx2440mm: Single Box 228mmx2440mm	20.7 kg
Single Box 230mmx2440mm: Single Box 230mmx2440mm	281.4 kg
Single Box 230mmx2440mm: Single Box 231mmx2440mm	20.9 kg
Single Box 230mmx2440mm: Single Box 235mmx2440mm	10.6 kg
Single Box 230mmx2440mm: Single Box 239mmx2440mm	32.1 kg
Single Box 230mmx2440mm: Single Box 241mmx2440mm	21.6 kg
Single Box 230mmx2440mm: Single Box 248mmx2440mm	22.0 kg
Single Box 230mmx2440mm: Single Box 251mmx2440mm	22.2 kg
Single Box 230mmx2440mm: Single Box 255mmx2440mm	22.4 kg
Single Box 230mmx2440mm: Single Box 259mmx2440mm	22.7 kg
Single Box 230mmx2440mm: Single Box 260mmx2440mm	56.9 kg
Single Box 230mmx2440mm: Single Box 270mmx2440mm	11.7 kg
Single Box 230mmx2440mm: Single Box 272mmx2440mm	82.4 kg
Single Box 230mmx2440mm: Single Box 290mmx2440mm	12.3 kg
Single Box 230mmx2440mm: Single Box 320mmx2440mm	359.1 kg
Single Box 230mmx2440mm: Single Box 327mmx2440mm	270.5 kg
Single Box 230mmx2440mm: Single Box 330.2mmx2440mm	95.4 kg
Single Box 230mmx2440mm: Single Box 331mmx2440mm	136.5 kg
Single Box 230mmx2440mm: Single Box 350mmx2440mm	484.9 kg
Single Box 230mmx2440mm: Single Box 355mmx2440mm	43.3 kg
Single Box 230mmx2440mm: Single Box 358mmx2440mm	14.5 kg
Single Box 230mmx2440mm: Single Box 432mmx2440mm	33.8 kg
Single Box 230mmx2440mm: Single Box 80mmx2440mm	16.9 kg
Single End Sheet 120mmx2440mmx12mm: Single End Sheet 120mmx2440mmx12mm	1.9 kg
Window Ope Center 910mm: Window Ope Center 910mm	3,292.3 kg
Window Ope Offset 910mm: Window Ope offset 910mm	2,676.2 kg
Window Ope Offset Half Window: Window Ope Offset Half Window	171.6 kg

Used in the following Tally entries:
Plywood, exterior grade

Description:
Plywood, unfinished

Life Cycle Inventory:
33% PNW
67% SE
Plywood

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)

Flooring, bamboo plank	430,321.9 kg
Used in the following Revit families:	
CLT Timber	253,299.2 kg
Cross Laminated Timber CLT	3,740.6 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NE-SE Corner Panel	743.6 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NW-SW Corner Panel	1,221.1 kg
Mass Bamboo Corner Panel: Mass Bamboo Corner Panel Full Height NE-SE	1,346.4 kg
Mass Bamboo Door Ope 900mm No Door: Mass Bamboo Door Ope 900mm No Door	1,142.9 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	15,292.9 kg
Mass Bamboo Double Window Ope Center 1820mm: Mass Bamboo Double Win...	6,188.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1000mm...	351.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1022mm...	1,316.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1058mm...	247.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1070mm...	125.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1100mm...	1,159.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1123mm...	1,183.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1127mm...	396.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1130mm...	661.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1145mm...	402.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1160mm...	271.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1192mm...	558.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1219mm...	713.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1220mm...	63,155.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1232mm...	144.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1252mm...	146.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1274mm...	298.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1300mm...	456.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1305mm...	152.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1340mm...	313.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1342mm...	157.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1352mm...	316.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1367mm...	160.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1383mm...	485.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1427mm...	835.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1435mm...	168.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1448mm...	339.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1450mm...	5,774.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1455mm...	170.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 151mmx...	70.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1547mm...	5,254.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1550.2...	1,270.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1578mm...	184.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1652mm...	387.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1702mm...	598.0 kg

LCA Metadata (continued)

Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1738mm...	203.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1740mm...	611.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1762mm...	206.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1764mm...	619.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1766mm...	206.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1800mm...	210.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1850mm...	1,733.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1860mm...	653.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mm...	881.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mm...	661.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1886mm...	662.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1918mm...	1,347.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 191mmx...	22.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1932mm...	226.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1941mm...	454.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1942mm...	3,184.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1944mm...	227.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1954mm...	2,288.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1996mm...	1,636.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2023mm...	710.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2038mm...	1,432.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2049mm...	719.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2056mm...	722.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2062mm...	241.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2064mm...	241.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2111mm...	989.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2196mm...	257.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2380mm...	4,459.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2440mm...	1,143.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2492mm...	2,918.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2760mm...	323.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 290mmx...	34.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 350mmx...	164.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 462mmx...	54.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 496mmx...	58.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 538mmx...	126.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 543mmx...	254.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 556mmx...	130.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 559mmx...	196.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 616.2m...	721.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 620mmx...	72.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 640mmx...	449.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 670mmx...	313.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 682mmx...	159.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 700mmx...	327.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 710mmx...	332.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 750mmx...	3,952.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 772mmx...	271.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 830mmx...	2,721.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 842mmx...	887.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 876.9m...	308.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 896mmx...	104.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 930mmx...	217.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 950mmx...	1,669.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 978mmx...	114.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1220mm...	3,257.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1320mm...	46.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1490mm...	418.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1530mm...	53.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1610mm...	396.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1990mm...	69.9 kg
Mass Bamboo Window Ope Center 910mm: Mass Bamboo Window Ope Center...	8,869.8 kg
Mass Bamboo Window Ope Offset 910mm: Mass Bamboo Window Ope Offset...	1,237.7 kg
Mass Bamboo Window Ope Single Plus Half 1260mm: Mass Bamboo Window ...	924.7 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Bamboo plank flooring

Life Cycle Inventory:
90% Bamboo, 10% phenol formaldehyde

Manufacturing Scope:
Cradle to gate for raw material only, includes transportation from China and estimate for material processing neglects materials for installation

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
CN: Bamboo (estimation) PE (2012)
GLO: Bulk commodity carrier PE (2012)
US: Heavy fuel oil at refinery (0.3wt.% S) PE (2010)
CN: Electricity grid mix PE (2010)
DE: Phenol formaldehyde resin PE (2012)

Glazing, triple, insulated (argon), low-E — 9,983.2 kg

Used in the following Revit families:

System Panel: Glazed	9,983.2 kg

Used in the following Tally entries:
Glazing, triple pane IGU

Description:
Glazing, triple, insulated (argon filled), 1/8" float glass, low-E, inclusive of argon gas fill, sealant, and spacers

Life Cycle Inventory:
32.4 kg/m² glass
Argon filled, 0.15 kg/m² low-e coating

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Insulation glass compound (3 panes) PE (2012)

Hardware, stainless steel — 9.7 kg

Used in the following Revit families:

Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	0.6 kg
IntSgl (7): 1010 x 2110mm	2.1 kg
IntSgl (7): 810 x 2110mm	3.1 kg
IntSgl (7): 910 x 2110mm	2.7 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	1.2 kg

Used in the following Tally entries:
Stainless steel, hardware

Description:
Finished, cast stainless steel entry applicable for door, window or other accessory hardware

Life Cycle Inventory:
Stainless steel

Manufacturing Scope:
Cradle to gate

End of Life Scope:
98% recovered (product has 58.1% scrap input while remainder is processed and credited as avoided burden)
2% landfilled (inert material)

Entry Source:
RER: Stainless steel Quarto plate (304) Eurofer (2008)
DE: Steel cast part machining PE (2012)
US: Electricity grid mix PE (2010)
RER: Stainless steel flat product (304) - value of scrap Eurofer (2008)

Interior grade plywood, US — 1,023.1 kg

Used in the following Revit families:

Stair	1,023.1 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Plywood, unfinished

Life Cycle Inventory:
33% PNW
67% SE
Plywood
Proxied by exterior grade plywood

Manufacturing Scope:
Cradle to gate

LCA Metadata (continued)

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)

None	0.0 kg

Used in the following Revit families:

Bamboo LVB	0.0 kg
CLT Timber	0.0 kg
Corner Balcony Panel SE-NE 732mmx120mm: Corner Balcony Panel SE-NE ...	0.0 kg
Corner Balcony Panel SW-NW 732mm height: Corner Balcony Panel SW-NW...	0.0 kg
Corner Panel NE Corner: Corner Panel NE Corner	0.0 kg
Cross Laminated Timber CLT	0.0 kg
Cross Laminated Timber Mass 100mm	0.0 kg
Cross Laminated Timber Mass 188mm	0.0 kg
Cross Laminated Timber Mass 300	0.0 kg
Door ope Panel 2440mmx1220mm w-900x2110 No Door: Door ope Panel 244...	0.0 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx...	0.0 kg
Generic Bamboo Mass 188mm	0.0 kg
Generic Bamboo Mass 300	0.0 kg
Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx1...	0.0 kg
Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx7...	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 100mm Width	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 270mm Width	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 310mm Width	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 390mm Width	0.0 kg
IntSgl (7): 1010 x 2110mm	0.0 kg
IntSgl (7): 810 x 2110mm	0.0 kg
IntSgl (7): 910 x 2110mm	0.0 kg
LVB Bamboo Floor	0.0 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NE-SE Corner Panel	0.0 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NW-SW Corner Panel	0.0 kg
Mass Bamboo Corner Panel: Mass Bamboo Corner Panel Full Height NE-SE	0.0 kg
Mass Bamboo Door Ope 900mm No Door: Mass Bamboo Door Ope 900mm No Door	0.0 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	0.0 kg
Mass Bamboo Double Window Ope Center 1820mm: Mass Bamboo Double Win...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1000mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1022mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1058mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1070mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1100mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1123mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1127mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1130mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1145mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1160mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1192mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1219mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1220mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1232mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1252mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1274mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1300mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1305mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1340mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1342mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1352mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1367mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1383mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1427mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1435mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1448mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1450mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1455mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 151mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1547mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1550.2...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1578mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1652mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1702mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1738mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1740mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1762mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1764mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1766mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1800mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1850mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1860mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1886mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1918mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 191mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1932mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1941mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1942mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1944mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1954mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1996mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2023mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2038mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2049mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2056mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2062mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2064mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2111mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2196mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2380mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2440mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2492mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2760mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 290mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 350mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 462mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 496mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 538mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 543mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 556mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 559mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 616.2m...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 620mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 640mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 670mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 682mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 700mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 710mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 750mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 772mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 830mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 842mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 876.9m...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 896mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 930mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 950mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 978mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1220mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1320mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1490mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1530mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1610mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1990mm...	0.0 kg
Mass Bamboo Window Ope Center 910mm: Mass Bamboo Window Ope Center ...	0.0 kg
Mass Bamboo Window Ope Offset 910mm: Mass Bamboo Window Ope Offset ...	0.0 kg
Mass Bamboo Window Ope Single Plus Half 1260mm: Mass Bamboo Window ...	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1000mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1022mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1058mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1070mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1100mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1130mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1145mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1160mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 1192mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 520mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid panel 538mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 546mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 554mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 616.2mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 616mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 620mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 630mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 662mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 666mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 670mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 682mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 698mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 710mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 712mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 722mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 724mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 730mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 734mm Width	0.0 kg

LCA Metadata (continued)

Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 750mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 772mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 776mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 803mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 818mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 829mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 830mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 832mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 836mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 842mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 876.9mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 877mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 891mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 900mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 930mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 950mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 976mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel 978mm Width	0.0 kg
Plywood Hybrid Panel Full Size: Plywood Hybrid Panel Full Size	0.0 kg
Quad Corner Mullion: Quad Mullion 1	0.0 kg
Rectangular Mullion: 50 x 120mm	0.0 kg
Rectangular Mullion: 50 x 120mm Bamboo	0.0 kg
Rectangular Mullion: 50 x 150mm	0.0 kg
Single Box 230mmx2440mm: Single Box 120mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 122mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 132mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 147mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 151mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 152mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 163.2mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 191mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 207mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 221mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 223.1mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 228mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 230mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 231mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 235mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 239mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 241mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 248mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 251mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 255mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 259mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 260mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 270mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 272mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 290mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 320mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 327mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 330.2mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 331mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 350mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 355mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 358mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 432mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 80mmx2440mm	0.0 kg
Single End Sheet 120mmx2440mmx12mm: Single End Sheet 120mmx2440mmx12mm	0.0 kg
Stair	0.0 kg
Window Ope Center 910mm: Window Ope Center 910mm	0.0 kg
Window Ope Offset 910mm: Window Ope offset 910mm	0.0 kg
Window Ope Offset Half Window: Window Ope Offset Half Window	0.0 kg

Used in the following Tally entries:
Aluminum mullion
Cross laminated timber (CrossLam / CLT)
Domestic softwood
Door, interior, wood, MDF core, flush
Flooring, bamboo plank
Flooring, engineered wood plank
Plywood, exterior grade

Description:
This entry is a placeholder, for use in cases when there is "no" finish, or "no added material designated.

Manufacturing Scope:
NA

Entry Source:
None

Paint, interior acrylic latex — 3.4 kg

Used in the following Revit families:
Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx... 3.4 kg

Used in the following Tally entries:
Domestic softwood

Description:
Application paint emulsion (building, interior, white, wear resistant)

Life Cycle Inventory:
2% organic solvents

Manufacturing Scope:
Cradle to gate, including emissions during application

End of Life Scope:
100% to landfill (plastic waste)

Entry Source:
DE: Application paint emulsion (building, interior, white, wear resistant) PE (2012)

Polyurethane floor finish, water-based — 203.3 kg

Used in the following Revit families:
Stair 203.3 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Water-based polyurethane wood stain, inclusive of catalyst

Life Cycle Inventory:
97.7% stain (50% water, 35% polyurethane dispersions, 5% dipropylene glycol dimethyl ether, 5% tri-butoxyethyl phosphate, 5% dipropylene glycol methyl ether), 2.3% catalyst (75% polyfunctional aziridine, 25% 2-propoxyethanol)
24.5% NMVOC emissions during application

Manufacturing Scope:
Cradle to gate, including emissions during application

End of Life Scope:
26.7% solids to landfill (plastic waste)

Entry Source:
DE: Ethylene glycol butyl ether PE (2012)
US: Epichlorohydrin (by product calcium chloride, hydrochloric acid) PE (2012)
DE: Propylenglycolmonomethylether (Methoxypropanol) PGME PE (2012)
US: Tap water from groundwater PE (2012)
DE: Polyurethane (copolymer-component) (estimation from TPU adhesive) PE (2012)
US: Electricity grid mix PE (2010)

Powder coating, metal stock — 72.9 kg

Used in the following Revit families:
1100mm 72.9 kg

Used in the following Tally entries:
Aluminum, extrusion

Description:
Powder coating, for metal stock

Manufacturing Scope:
Cradle to gate, including application

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Application top coat powder (aluminium) PE (2012)
DE: Coating powder (industry
outside
red) PE (2012)

LCA Metadata (continued)

Stainless steel, door hardware, lever lock, interior, residential	2,302.9 kg
Used in the following Revit families:	
Door ope Panel 2440mmx1220mm w-900x2110 ope: Door ope Panel 2440mmx	708.2 kg
IntSgl (7): 1010 x 2110mm	48.2 kg
IntSgl (7): 810 x 2110mm	69.5 kg
IntSgl (7): 910 x 2110mm	60.8 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	1,416.3 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Stainless steel door fitting (hinges and lockset) for use on residential interior door assemblies.

Life Cycle Inventory:
Door hinges 0.622 kg/part, Battalion Lever Lockset, Light Duty, Privacy 0.70 kg/part

Manufacturing Scope:
Cradle to gate, including disposal of packaging.

End of Life Scope:
90% collection rate
remaining 10% deposited in the LCA model without recycling
material recycling efficiency dependant on the metal (89% steel, 90.2% aluminum, stainless steel 83%, zinc 91%, brass 94%)
Plastic components incinerated resulting in credits for electricity and thermal energy

Entry Source:
DE: Fitting stainless steel - FSB (2009)

Veneer, hardwood	307.1 kg
Used in the following Revit families:	
Stair	307.1 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Hardwood veneer

Life Cycle Inventory:
43% PNW
57% SE
veneer

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% landfilled (biodegradable waste)

Entry Source:
US: Dry veneer, at plywood plant, PNW USLCI/PE (2009)
US: Dry veneer, at plywood plant, SE USLCI/PE (2009)

Stadthaus, Murray Grove

12mm thick 128mm LVB v 128mm CLT

01/03/2016

Table of Contents

Report Summary

Created with Tally
Non-commercial Version 2014.06.17.01

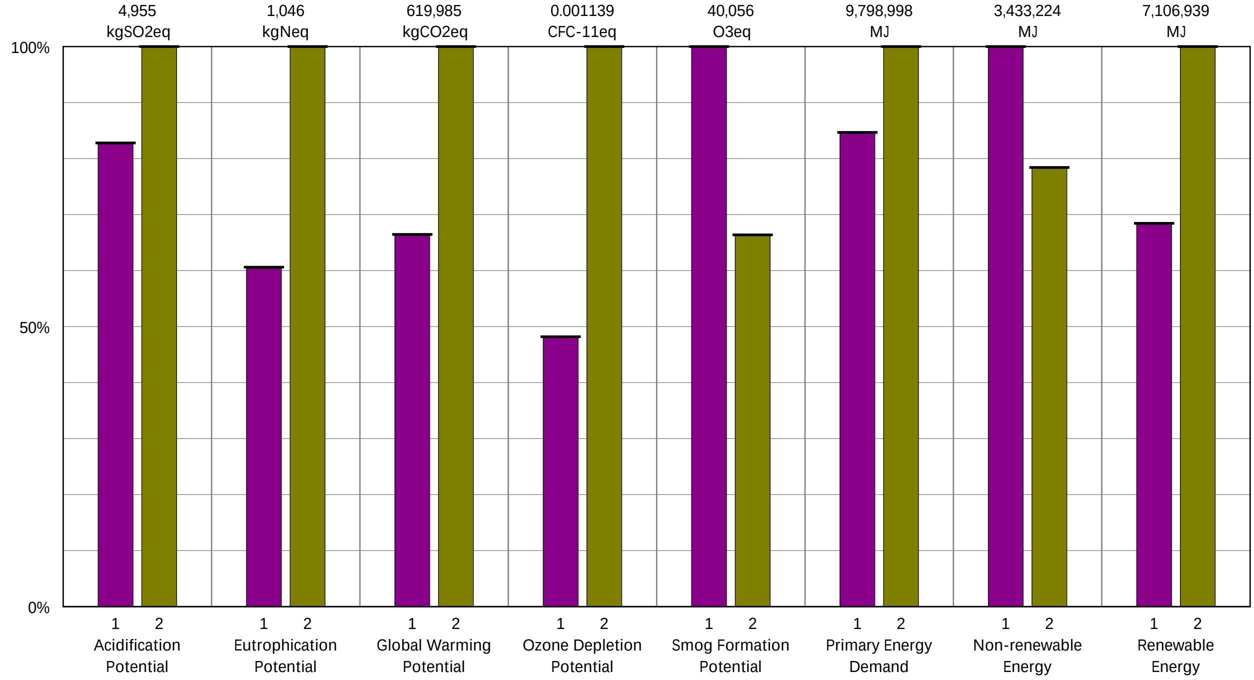
Author : Philip Kavanagh
Company : Dublin Institute of Technology
Date : 01/03/2016

Project : Stadthaus, Murray Grove
Location : London, England
Gross Area : 2782.998 m²
Building Life : 50

Scope : Cradle-to-Grave, exclusive of operational energy

Goal of Assessment :
To determine the global warming potential, through life cycle analysis, of laminated veneer bamboo diaphragm panel construction over the selection of cross laminated timber panels for use in mid to high rise residential accommodation.

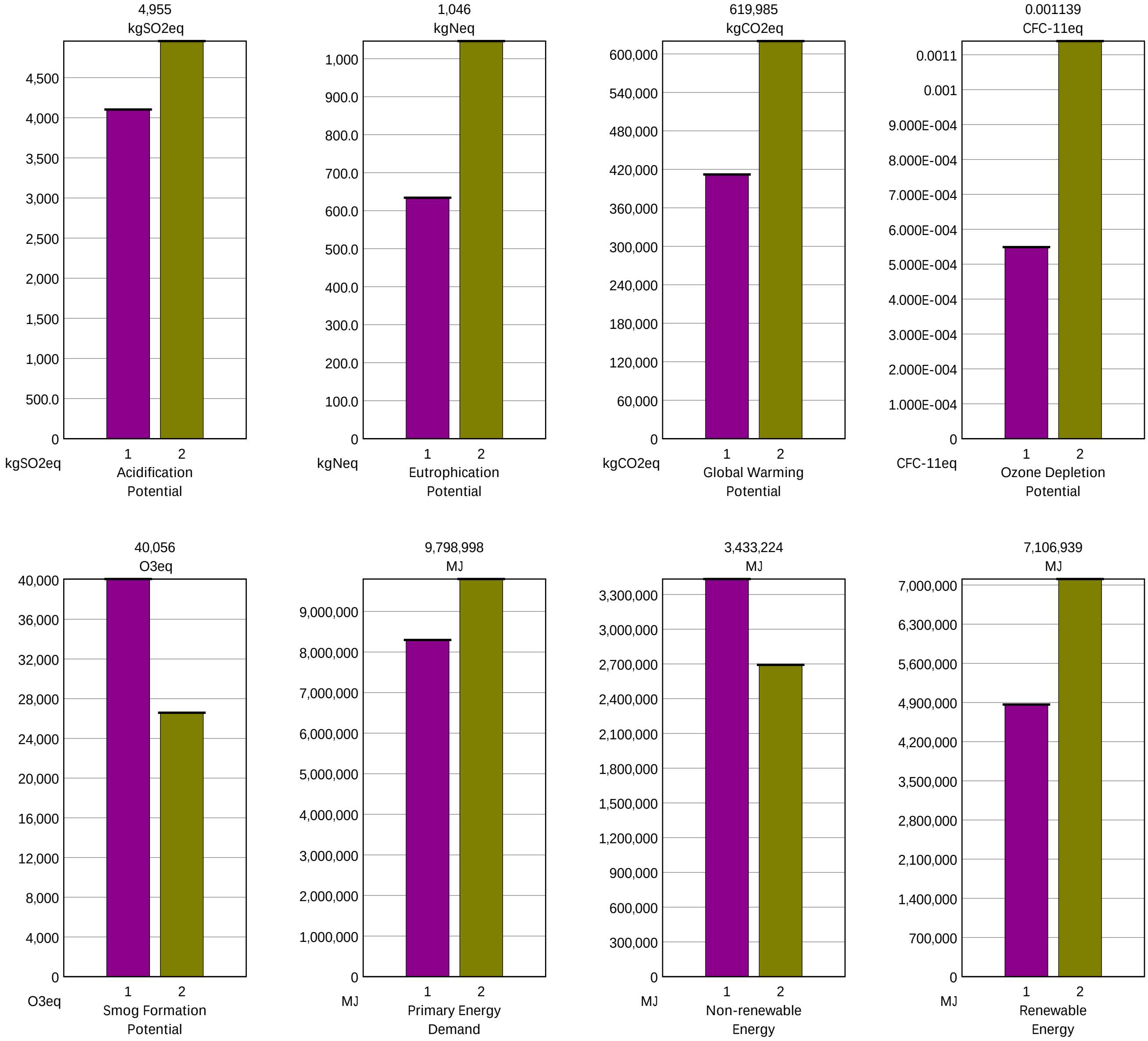
Object of Study
Design options set 'Option Set 1'
Bamboo LVB Hybrid Box (primary)
Cross Laminated Timber



Legend

Design Options
- Bamboo LVB Hybrid Box (primary)
- Cross Laminated Timber

Report Summary (continued)

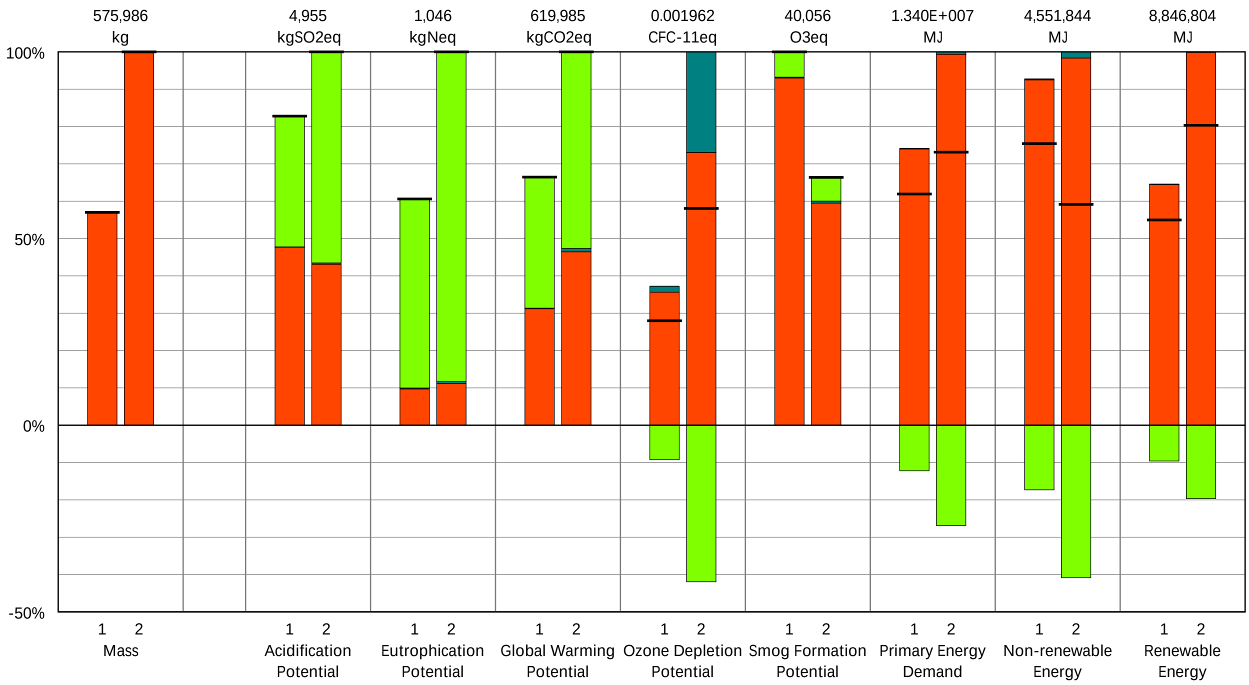


Legend

Design Options

- Bamboo LVB Hybrid Box (primary)
- Cross Laminated Timber

Results per Life Cycle Stage



Legend

Net value (impacts + credits)

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

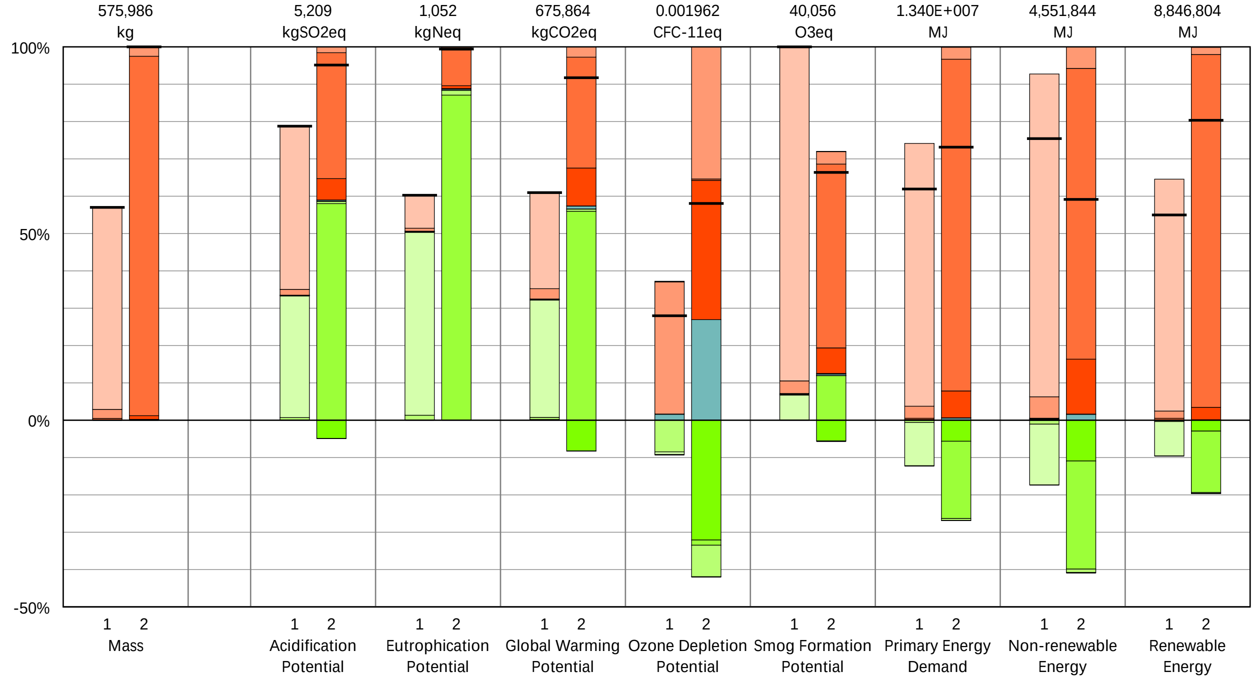
Life Cycle Stages

Manufacturing

Maintenance and Replacement

End of Life

Results per Life Cycle Stage, itemized by CSI Division



Legend

Net value (impacts + credits)

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Manufacturing

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

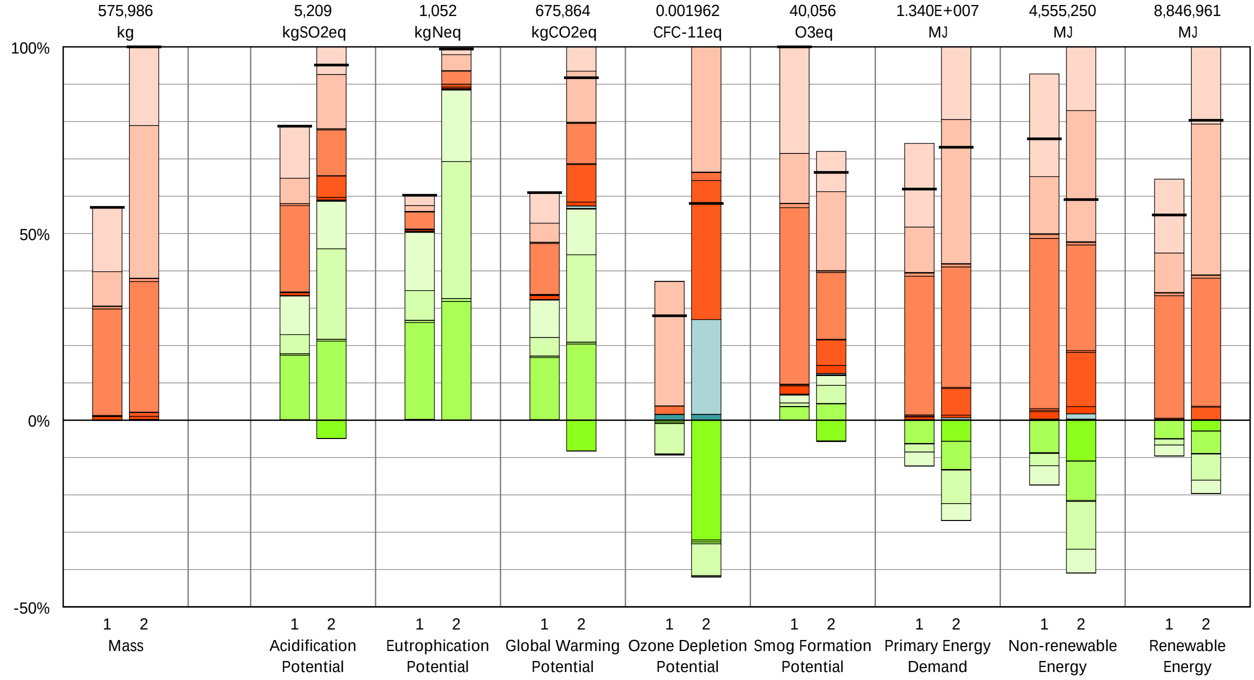
Maintenance and Replacement

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

End of Life

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

Results per Life Cycle Stage, itemized by Revit Category



Legend

Net value (impacts + credits)

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Manufacturing

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

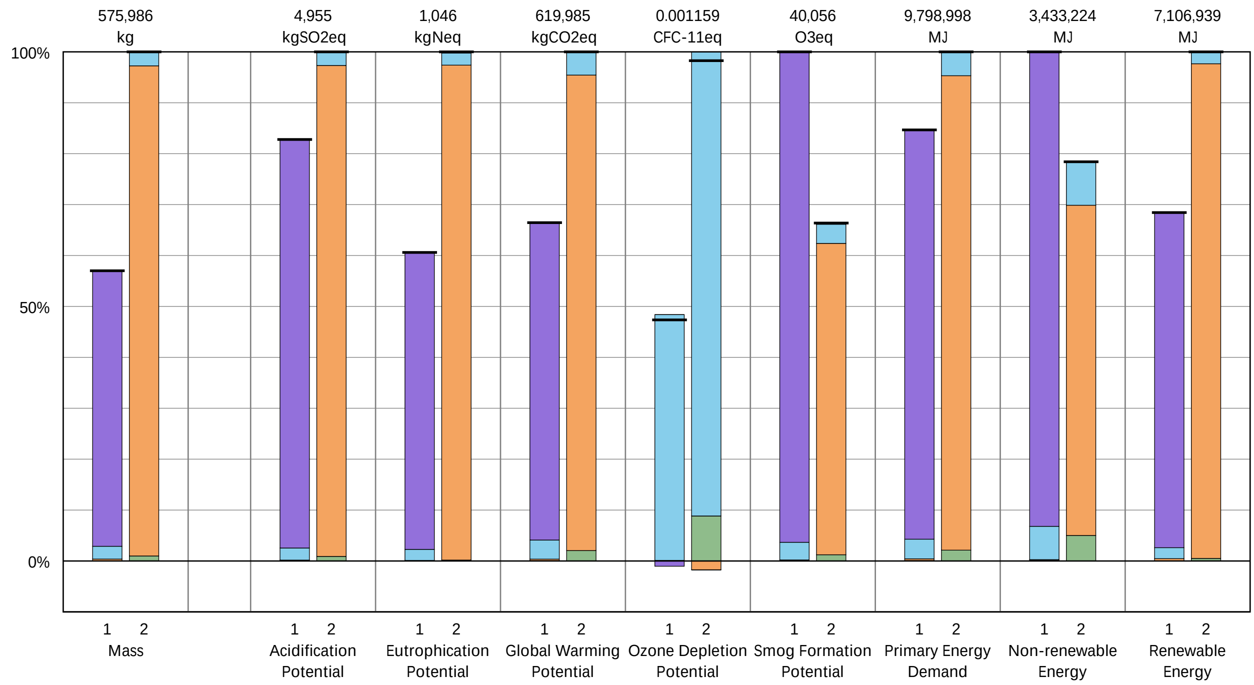
Maintenance and Replacement

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

End of Life

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per CSI Division



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

CSI Divisions

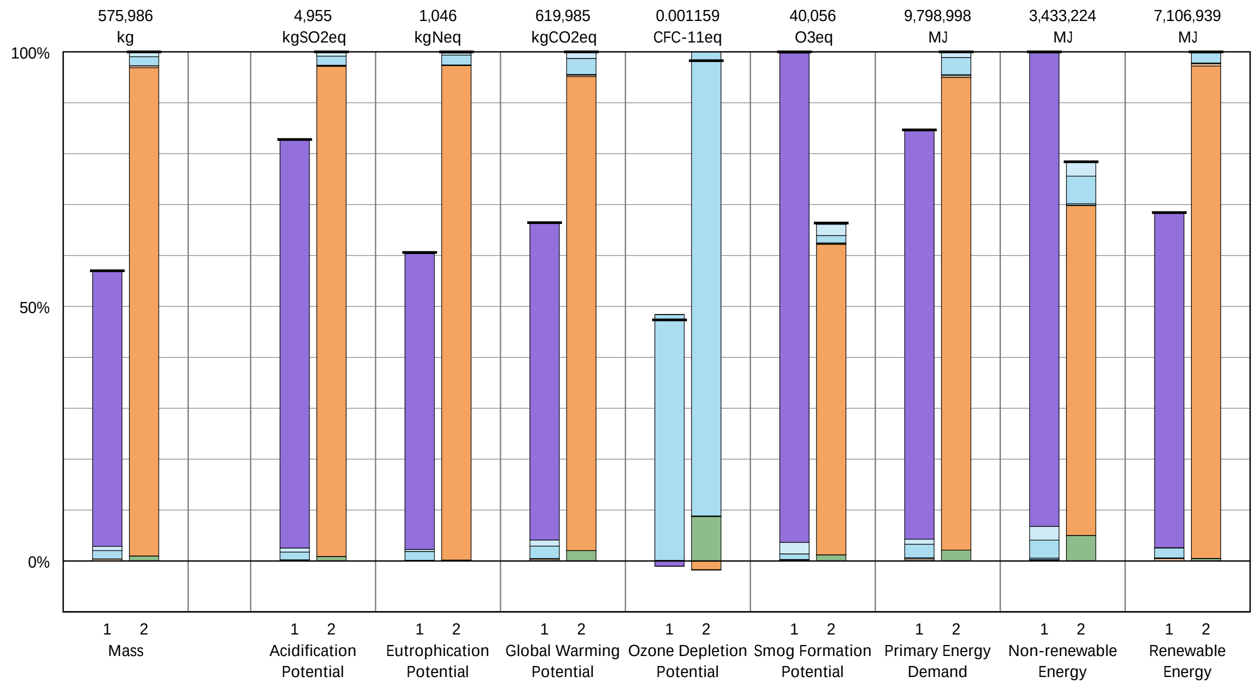
05 - Metals

06 - Wood/Plastics/Composites

08 - Openings and Glazing

09 - Finishes

Results per CSI Division, itemized by Tally Entry



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

05 - Metals

- Aluminum, extrusion
- Stainless steel, hardware

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam / CLT)
- Domestic softwood

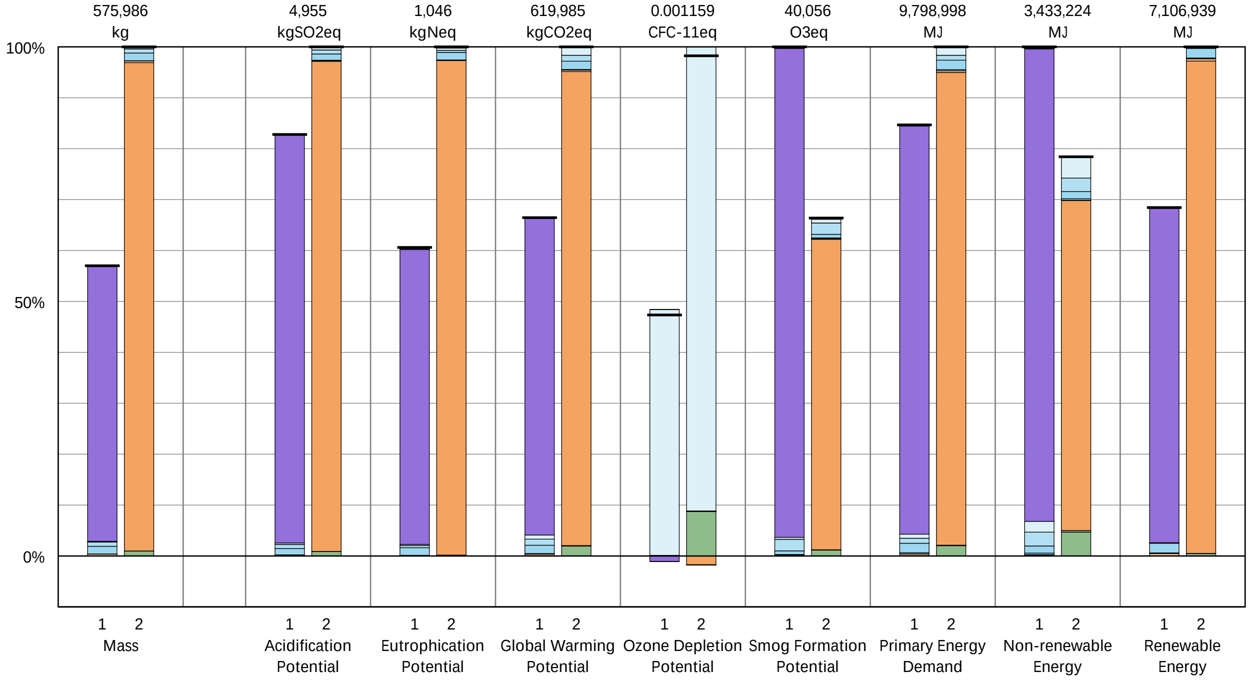
08 - Openings and Glazing

- Door frame, wood
- Door, interior, wood, MDF core, flush
- Glazing, triple pane IGU

09 - Finishes

- Flooring, bamboo plank
- Flooring, engineered wood plank

Results per CSI Division, itemized by Material



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

05 - Metals

- Aluminum, extruded
- Hardware, stainless steel
- Powder coating, metal stock

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam)
- Domestic softwood, US
- None

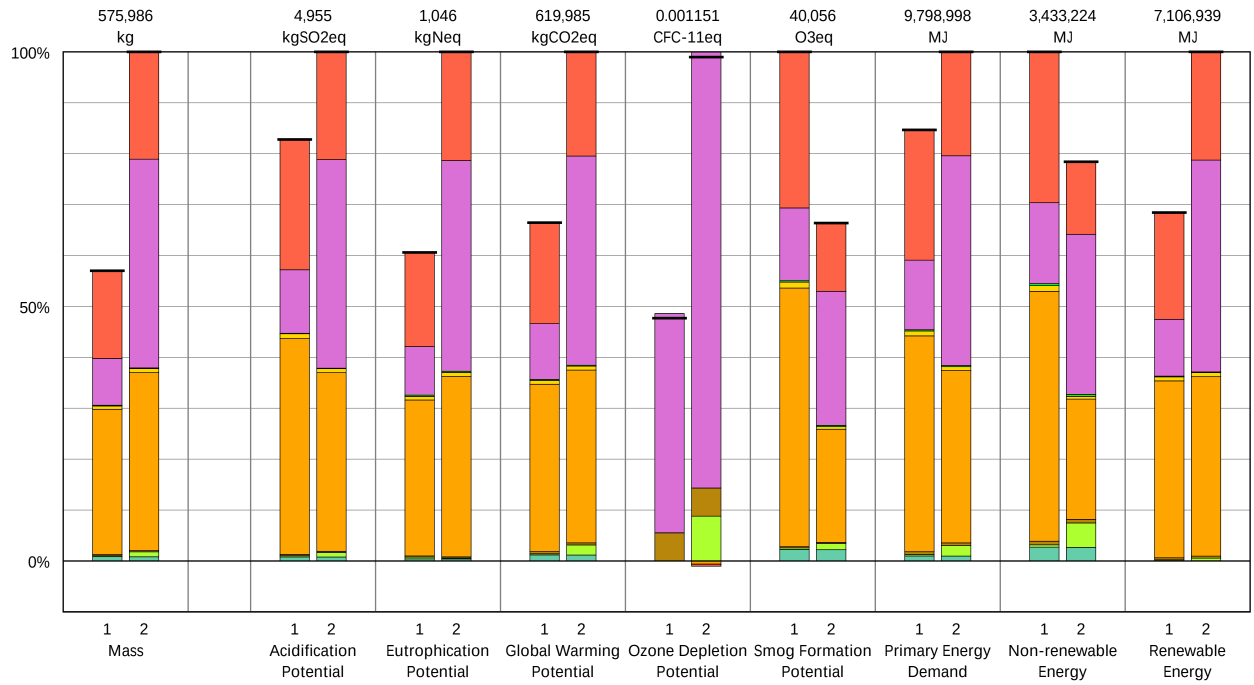
08 - Openings and Glazing

- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Glazing, triple, insulated (argon), low-E
- None
- Stainless steel, door hardware, lever lock, interior, residential

09 - Finishes

- Flooring, bamboo plank
- Interior grade plywood, US
- None
- Polyurethane floor finish, water-based
- Urethane adhesive
- Veneer, hardwood

Results per Revit Category



Legend

Design Options

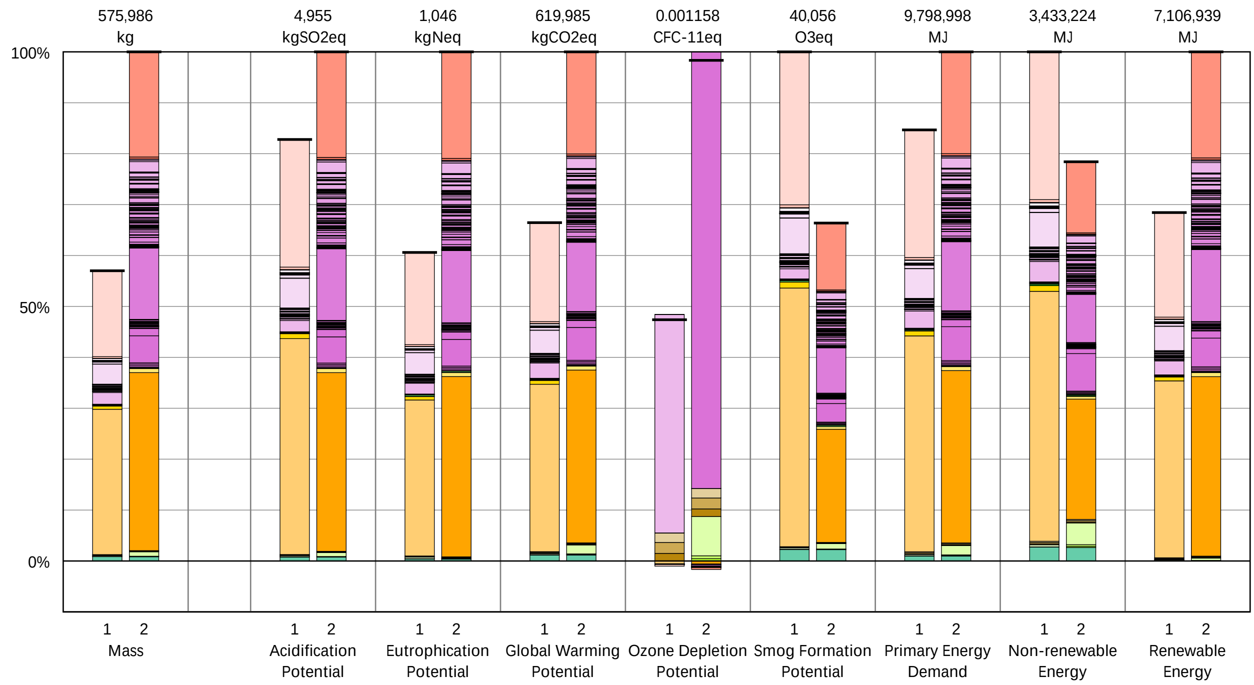
Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Revit Categories

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per Revit Category, itemized by Family



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- System Panel: Glazed

Curtain Wall Mullions

- Quad Corner Mullion: Quad Mullion 1
- Quad Corner Mullion: Quad Mullion Bamboo
- Rectangular Mullion: 50 x 120mm
- Rectangular Mullion: 50 x 120mm Bamboo
- Rectangular Mullion: 50 x 150mm
- Rectangular Mullion: 50 x 150mm Bamboo

Doors

- IntSgl (7): 1010 x 2110mm
- IntSgl (7): 810 x 2110mm
- IntSgl (7): 910 x 2110mm

Floors

- CLT Timber
- LVB Bamboo Floor

Roofs

- Bamboo LVB
- Cross Laminated Timber CLT

Stairs and Railings

- 1100mm
- Stair

Structure

- CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel
- CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel
- CLT Corner Panel: CLT Corner Panel Full Height NE-SE
- CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door
- CLT Door Ope 900mm: CLT Door Ope 900mm
- CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1820mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1006mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1014mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1022mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1058mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1078mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1092mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1100mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1274mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1284mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1539mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1578mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1652mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1702mmx2440mm

Results per Revit Category, itemized by Family (continued)

Legend (continued)

- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1738mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1740mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1756mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1764mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1850mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1852mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1860mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1876mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1878mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm 2
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1910mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1941mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1942mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1991mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2002.2mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2033mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2038mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2048mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2049mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2372mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2380mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2440mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2484mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 616.2mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 620mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 640mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 648mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 830mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 842mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 877mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 950mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 978mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1610mmx732mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1990mmx732mm
- CLT Window Ope Center 910mm: CLT Window Ope Center 910mm
- CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm
- CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus Half 1260mm
- Corner Balcony Panel SE-NE 732mmx120mm: Corner Balcony Panel SE-NE 732mmx120mm
- Corner Balcony Panel SW-NW 732mm height: Corner Balcony Panel SW-NW 732mm height
- Corner Panel NE Corner 128mm: Corner Panel NE Corner 128mm
- Door ope Panel 2440mmx1220mm w-900x2110 No Door: Door ope Panel 2440mmx1220mm...
- Door ope Panel 2440mmx1220mm w-900x2110 ope Adaptable: Door ope Panel 2440mmx...
- Half Panel for Balcony 732mmx1220mm Adaptable: Half Panel for Balcony 732mmx1...
- Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx770mm
- Half Panel Single 230mm Width: Half Panel Single 100mm Width
- Half Panel Single 230mm Width: Half Panel Single 270mm Width
- Half Panel Single 230mm Width: Half Panel Single 310mm Width
- Half Panel Single 230mm Width: Half Panel Single 390mm Width
- LVB Panel Full Size: LVB Panel 1000mm Width
- LVB Panel Full Size: LVB Panel 1014mm Width
- LVB Panel Full Size: LVB Panel 1022mm Width
- LVB Panel Full Size: LVB Panel 1036mm Width
- LVB Panel Full Size: LVB Panel 1058mm Width
- LVB Panel Full Size: LVB Panel 1078mm Width
- LVB Panel Full Size: LVB Panel 1100mm Width
- LVB Panel Full Size: LVB Panel 1130mm Width
- LVB Panel Full Size: LVB Panel 1145mm Width
- LVB Panel Full Size: LVB Panel 1152mm Width
- LVB Panel Full Size: LVB Panel 1160mm Width
- LVB Panel Full Size: LVB Panel 1192mm Width
- LVB Panel Full Size: LVB Panel 520mm Width
- LVB Panel Full Size: LVB Panel 538mm Width
- LVB Panel Full Size: LVB Panel 554mm Width
- LVB Panel Full Size: LVB Panel 616.2mm Width
- LVB Panel Full Size: LVB Panel 616mm Width
- LVB Panel Full Size: LVB Panel 620mm Width
- LVB Panel Full Size: LVB Panel 630mm Width
- LVB Panel Full Size: LVB Panel 662mm Width
- LVB Panel Full Size: LVB Panel 666mm Width
- LVB Panel Full Size: LVB Panel 670mm Width
- LVB Panel Full Size: LVB Panel 682mm Width
- LVB Panel Full Size: LVB Panel 690mm Width
- LVB Panel Full Size: LVB Panel 698mm Width
- LVB Panel Full Size: LVB Panel 702mm Width
- LVB Panel Full Size: LVB Panel 710mm Width
- LVB Panel Full Size: LVB Panel 712mm Width
- LVB Panel Full Size: LVB Panel 722mm Width
- LVB Panel Full Size: LVB Panel 730mm Width
- LVB Panel Full Size: LVB Panel 732mm Width
- LVB Panel Full Size: LVB Panel 734mm Width
- LVB Panel Full Size: LVB Panel 750mm Width
- LVB Panel Full Size: LVB Panel 760mm Width
- LVB Panel Full Size: LVB Panel 770mm Width
- LVB Panel Full Size: LVB Panel 772mm Width
- LVB Panel Full Size: LVB Panel 776mm Width
- LVB Panel Full Size: LVB Panel 803mm Width
- LVB Panel Full Size: LVB Panel 818mm Width
- LVB Panel Full Size: LVB Panel 821mm Width
- LVB Panel Full Size: LVB Panel 826mm Width
- LVB Panel Full Size: LVB Panel 829mm Width
- LVB Panel Full Size: LVB Panel 830mm Width
- LVB Panel Full Size: LVB Panel 832mm Width
- LVB Panel Full Size: LVB Panel 836mm Width
- LVB Panel Full Size: LVB Panel 842mm Width
- LVB Panel Full Size: LVB Panel 876.9mm Width
- LVB Panel Full Size: LVB Panel 877mm Width
- LVB Panel Full Size: LVB Panel 891mm Width
- LVB Panel Full Size: LVB Panel 900mm Width
- LVB Panel Full Size: LVB Panel 922mm Width
- LVB Panel Full Size: LVB Panel 930mm Width
- LVB Panel Full Size: LVB Panel 950mm Width
- LVB Panel Full Size: LVB Panel 976mm Width
- LVB Panel Full Size: LVB Panel 978mm Width
- LVB Panel Full Size: LVB Panel Full Size
- LVB Panel Full Size: LVB Panel Full Size 1212
- LVB Panel Full Size: LVB Panel Full Size 1216
- LVB Window Ope Center 910mm: LVB Window Ope Center 910mm
- Single Box 230mmx2440mm: Single Box 120mmx2440mm
- Single Box 230mmx2440mm: Single Box 122mmx2440mm
- Single Box 230mmx2440mm: Single Box 132mmx2440mm
- Single Box 230mmx2440mm: Single Box 147mmx2440mm
- Single Box 230mmx2440mm: Single Box 151mmx2440mm
- Single Box 230mmx2440mm: Single Box 160mmx2440mm
- Single Box 230mmx2440mm: Single Box 163.2mmx2440mm
- Single Box 230mmx2440mm: Single Box 191mmx2440mm

Results per Revit Category, itemized by Family (continued)

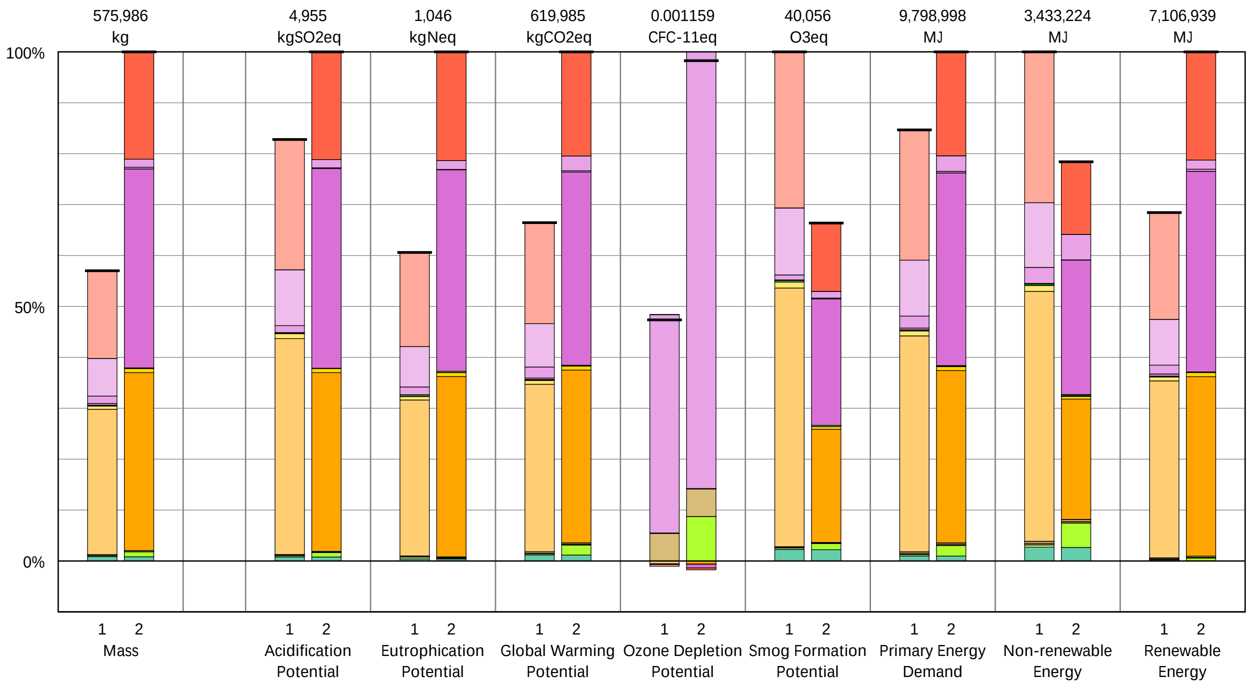
Legend (continued)

- Single Box 230mmx2440mm: Single Box 214mmx2440mm
- Single Box 230mmx2440mm: Single Box 221mmx2440mm
- Single Box 230mmx2440mm: Single Box 222mmx2440mm
- Single Box 230mmx2440mm: Single Box 223.1mmx2440mm
- Single Box 230mmx2440mm: Single Box 228mmx2440mm
- Single Box 230mmx2440mm: Single Box 230mmx2440mm
- Single Box 230mmx2440mm: Single Box 231mmx2440mm
- Single Box 230mmx2440mm: Single Box 241mmx2440mm
- Single Box 230mmx2440mm: Single Box 248mmx2440mm
- Single Box 230mmx2440mm: Single Box 251mmx2440mm
- Single Box 230mmx2440mm: Single Box 255mmx2440mm
- Single Box 230mmx2440mm: Single Box 259mmx2440mm
- Single Box 230mmx2440mm: Single Box 260mmx2440mm
- Single Box 230mmx2440mm: Single Box 264mmx2440mm
- Single Box 230mmx2440mm: Single Box 270mmx2440mm
- Single Box 230mmx2440mm: Single Box 272mmx2440mm
- Single Box 230mmx2440mm: Single Box 282mmx2440mm
- Single Box 230mmx2440mm: Single Box 310mmx2440mm
- Single Box 230mmx2440mm: Single Box 320mmx2440mm
- Single Box 230mmx2440mm: Single Box 322mmx2440mm
- Single Box 230mmx2440mm: Single Box 327mmx2440mm
- Single Box 230mmx2440mm: Single Box 330.2mmx2440mm
- Single Box 230mmx2440mm: Single Box 331mmx2440mm
- Single Box 230mmx2440mm: Single Box 334mmx2440mm
- Single Box 230mmx2440mm: Single Box 342mmx2440mm
- Single Box 230mmx2440mm: Single Box 355mmx2440mm
- Single Box 230mmx2440mm: Single Box 358mmx2440mm
- Single Box 230mmx2440mm: Single Box 432mmx2440mm
- Single Box 230mmx2440mm: Single Box 72mmx2440mm
- Window Ope Offset 910mm: Window Ope offset 910mm
- Window Ope Offset Half Window: Window Ope Offset Half Window

Walls

- Cross Laminated Timber Mass 100mm
- Cross Laminated Timber Mass 188mm
- Cross Laminated Timber Mass 300
- Generic Bamboo Mass 100
- Generic Bamboo Mass 188mm
- Generic Bamboo Mass 300

Results per Revit Category, itemized by Tally Entry



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- Glazing, triple pane IGU

Curtain Wall Mullions

- Aluminum, extrusion
- Flooring, bamboo plank

Doors

- Domestic softwood
- Door frame, wood
- Door, interior, wood, MDF core, flush
- Stainless steel, hardware

Floors

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Roofs

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Stairs and Railings

- Aluminum, extrusion
- Flooring, engineered wood plank

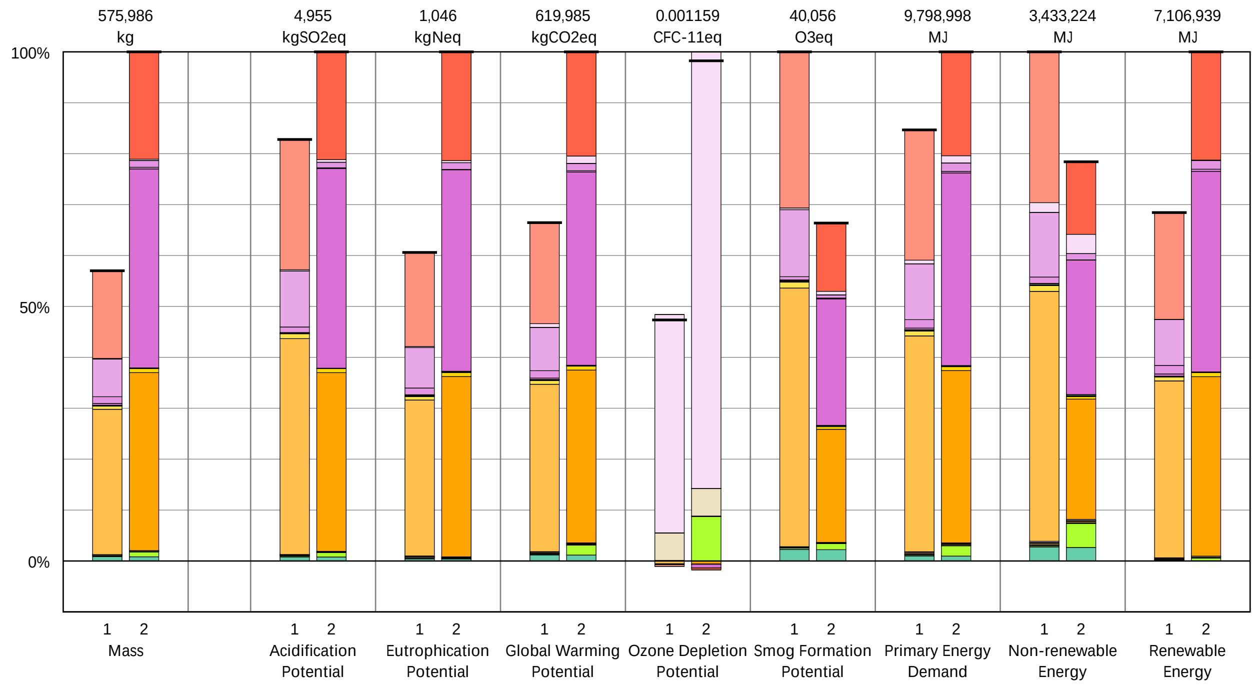
Structure

- Cross laminated timber (CrossLam / CLT)
- Domestic softwood
- Door, interior, wood, MDF core, flush
- Flooring, bamboo plank
- Stainless steel, hardware

Walls

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Results per Revit Category, itemized by Material



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- Glazing, triple, insulated (argon), low-E

Curtain Wall Mullions

- Aluminum, extruded
- Flooring, bamboo plank
- Polyurethane floor finish, water-based
- Powder coating, metal stock
- Urethane adhesive

Doors

- Domestic softwood, US
- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Hardware, stainless steel
- None
- Stainless steel, door hardware, lever lock, interior, residential

Floors

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Roofs

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Stairs and Railings

- Aluminum, extruded
- Interior grade plywood, US
- None
- Polyurethane floor finish, water-based
- Powder coating, metal stock
- Veneer, hardwood

Structure

- Cross laminated timber (CrossLam)
- Domestic softwood, US
- Door, interior, wood, MDF Core, flush
- Flooring, bamboo plank
- Hardware, stainless steel
- None
- Stainless steel, door hardware, lever lock, interior, residential

Walls

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Calculation Methodology

Studied objects

The LCA results in the report represent either an analysis of a single building, or a comparative analysis of two or more building design options. The single building may represent the complete architectural, structural, and finish systems of a building or a subset of those systems, and it may be used to compare the relative contributions of building systems to environmental impacts and for comparative study with one or more reference buildings. The comparison of design options may represent a full building in various stages of the design process, or they may represent multiple schemes of a full or partial building that are being compared to one another across a range of evaluation criteria.

Functional unit and reference flow

The functional unit of the analysis is the usable floor space of the building under study. For a design option comparison of a partial building, the functional unit is the complete set of building systems that performs a given function. The reference flow is the amount of material required to produce a building, or portion thereof, designed according to the given goal and scope of the assessment, over the full life of the building. If operational energy is included in the assessment the reference flow also includes the electrical and thermal energy consumed on site over the life of the building. It is the responsibility of the modeler to assure that reference buildings or design options are functionally equivalent in terms of scope, size, and relevant performance. The expected life of the building has a default value of 60 years and can be modified by the model author.

System boundaries and delimitations

The analysis accounts for the full cradle-to-grave life cycle of the design options studied, including material manufacturing, maintenance and replacement, and eventual end-of-life (disposal, incineration, and/or recycling), including the materials and energy used across all life cycle stages. Optionally, the operational energy of the building can be included within the scope.

Architectural materials and assemblies include all materials required for the product's manufacturing and use (including hardware, sealants, adhesives, coatings, and finishing, etc.) up to a 1% cut-off factor by mass with the exception of known materials that have high environmental impacts at low levels. In these cases, a 1% cut-off was implemented by impact.

Manufacturing includes cradle-to-gate manufacturing wherever possible. This includes raw material extraction and processing, intermediate transportation, and final manufacturing and assembly. Due to data limitations, however, some manufacturing steps have been excluded, such as the material and energy requirements for assembling doors and windows. The manufacturing scope is listed for each entry, detailing any specific inclusions or exclusions that fall outside of the cradle-to-gate scope.

Transportation of upstream raw materials or intermediate products to final manufacturing is generally included in the GaBi datasets utilized within this tool. Transportation requirements between the manufacturer and installation of the product, and at the end-of-life of the product, are excluded from this study.

Infrastructure (buildings and machinery) required for the manufacturing and assembly of building materials, as well as packaging materials, are not included and are considered outside the scope of assessment.

Maintenance and replacement encompasses the replacement of materials in accordance with the expected service life. This includes the end-of-life treatment of the existing products and cradle-to-gate manufacturing of the replacement products. The service life is specified separately for each product.

Operational energy treatment is based on the anticipated energy consumed at the building site over the lifetime of the building. Each energy dataset includes relevant upstream impacts associated with extraction of energy resources (e.g., coal, crude oil), refining, combustion, transmission, losses, and other associated factors. US electricity generation datasets are based on subregions from US EPA's eGRID2012 database v1.0, but adapted to account for imports and exports into these regions. These consumption mixes - unique to the GaBi databases - provide a more accurate reflection of impacts associated with electricity consumption.

End-of-life treatment is based on average US construction and demolition waste treatment methods and rates. This includes the relevant material collection rates for recycling, processing requirements for recycled materials, incineration rates, and landfilling rates. Along with processing requirements, the recycling of materials is modeled using an avoided burden approach, where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material. Incineration of materials includes credit for average US energy recovery rates. The impacts associated with landfilling are based on average material properties, such as plastic waste, biodegradable waste, or inert material. Specific end-of-life scenarios are detailed for each entry.

Data source and quality

Tally utilizes a custom designed LCA database that combines material attributes, assembly details, and engineering and architectural specifications with environmental impact data resulting from the collaboration between KieranTimberlake and PE INTERNATIONAL. LCA modeling was conducted in GaBi 6 using GaBi databases and in accordance with GaBi database and modeling principles.

Geography and date: The data used are intended to represent the US and the year 2013. Where representative data were unavailable, proxy data were used. The datasets used, their geographic region, and year of reference are listed for each entry. An effort was made to choose proxy datasets that are technologically consistent with the relevant entry.

Uncertainty in results can stem from both the data used and the application of the data. Data quality is judged by its precision (measured, calculated, or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological). The LCI data sets from the GaBi LCI databases have been used in LCA models worldwide in industrial and scientific applications, both as internal and critically reviewed and published studies. The uncertainty introduced by the use of any proxy data is reduced by using technologically, geographically, and/or temporally similar data. It is the responsibility of the modeler to apply the predefined material entries appropriately to the building under study.

Tally methodology is consistent with LCA standards ISO 14040-14044.

Glossary of LCA Terminology

Environmental Impact Categories

The following list provides a description of environmental impact categories reported according to the TRACI 2.1 characterization scheme. References: [Bare 2010, EPA 2012, Guinée 2001]

Acidification Potential (AP) kg SO2 eq

A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline, and the deterioration of building materials.

Eutrophication Potential (EP) kg N eq

Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.

Global Warming Potential (GWP) kg CO2 eq

A measure of greenhouse gas emissions, such as CO2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health, and material welfare.

Ozone Depletion Potential (ODP) kg CFC-11 eq

A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants.

Smog Formation Potential (SFP) kg O3 eq

Ground level ozone is created by various chemical reactions, which occur between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in sunlight. Human health effects can result in a variety of respiratory issues including increasing symptoms of bronchitis, asthma, and emphysema. Permanent lung damage may result from prolonged exposure to ozone. Ecological impacts include damage to various ecosystems and crop damage. The primary sources of ozone precursors are motor vehicles, electric power utilities, and industrial facilities.

Primary Energy Demand (PED) MJ (lower heating value)

A measure of the total amount of primary energy extracted from the earth. PED is expressed in energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.) and energy demand from renewable resources (e.g. hydropower, wind energy, solar, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account.

LCA Metadata

NOTES

The following list provides a summary of all materials and energy inputs present in the selected study. Materials are listed in alphabetical order along with a list of all Revit families and Tally entries in which they occur and any notes and system boundaries accompanying their database entries. The mass given here refers to the full life-cycle mass of material, including manufacturing and replacement.

Aluminum, extruded	5,621.2 kg

Used in the following Revit families:

1100mm	0.0 kg
Quad Corner Mullion: Quad Mullion 1	288.1 kg
Rectangular Mullion: 50 x 120mm	363.0 kg
Rectangular Mullion: 50 x 150mm	4,970.1 kg

Used in the following Tally entries:
Aluminum, extrusion

Description:
Extruded aluminum part

Life Cycle Inventory:
Aluminum, process energy

Manufacturing Scope:
Cradle to gate

End of Life Scope:
95% recovered (includes recycling, scrap preparation, and avoided burden credit)
5% landfilled (inert material)

Entry Source:
NA: Primary Aluminium Ingot AA (2011)
EU-27: Aluminium extrusion profile PE (2012)

Cross laminated timber (CrossLam)	552,386.1 kg

Used in the following Revit families:

CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel	967.5 kg
CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel	1,589.3 kg
CLT Corner Panel: CLT Corner Panel Full Height NE-SE	1,752.0 kg
CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door	1,493.4 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	19,467.7 kg
CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1	8,086.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm	459.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1006mmx2440mm	154.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1014mmx2440mm	1,396.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1022mmx2440mm	156.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1058mmx2440mm	303.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1078mmx2440mm	165.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1092mmx2440mm	334.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1100mmx2440mm	673.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1107mmx2440mm	169.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1115mmx2440mm	341.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1123mmx2440mm	1,031.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1127mmx2440mm	485.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1130mmx2440mm	810.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1145mmx2440mm	525.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1160mmx2440mm	355.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1192mmx2440mm	729.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1204mmx2440mm	184.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1212mmx2440mm	1,483.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1219mmx2440mm	746.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1220mmx2440mm	80,656.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1228mmx2440mm	187.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1232mmx2440mm	377.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1260mmx2440mm	192.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1274mmx2440mm	389.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1284mmx2440mm	368.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1286mmx2440mm	184.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1305mmx2440mm	187.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1334mmx2440mm	191.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1340mmx2440mm	820.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1352mmx2440mm	581.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1375mmx2440mm	210.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1383mmx2440mm	634.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1411mmx2440mm	2,375.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1434mmx2440mm	5,266.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1435mmx2440mm	219.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1442mmx2440mm	2,206.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1448mmx2440mm	443.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1455mmx2440mm	222.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 151mmx2440mm	86.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1531mmx2440mm	3,045.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1539mmx2440mm	2,355.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1542.8mmx2440mm	236.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm	1,423.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1578mmx2440mm	241.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1652mmx2440mm	474.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1702mmx2440mm	781.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1738mmx2440mm	266.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1740mmx2440mm	798.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1756mmx2440mm	537.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1764mmx2440mm	539.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1800mmx2440mm	275.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1850mmx2440mm	2,123.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1852mmx2440mm	283.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1860mmx2440mm	569.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1876mmx2440mm	287.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1878mmx2440mm	862.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm	1,152.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm 2	576.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1910mmx2440mm	1,753.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm	29.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1932mmx2440mm	591.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1941mmx2440mm	297.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1942mmx2440mm	3,863.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1944mmx2440mm	297.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1946mmx2440mm	595.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1950mmx2440mm	298.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1954mmx2440mm	2,392.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1973mmx2440mm	603.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1988mmx2440mm	912.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1991mmx2440mm	609.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2002.2mmx2440mm	306.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm	928.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2033mmx2440mm	622.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2038mmx2440mm	1,871.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2048mmx2440mm	313.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2049mmx2440mm	313.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2050mmx2440mm	313.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2056mmx2440mm	629.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2064mmx2440mm	315.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2111mmx2440mm	1,211.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2196mmx2440mm	336.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2372mmx2440mm	5,082.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2380mmx2440mm	728.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2440mmx2440mm	1,400.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2484mmx2440mm	2,280.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2492mmx2440mm	1,525.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2760mmx2440mm	396.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 290mmx2440mm	44.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 350mmx2440mm	200.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 462mmx2440mm	70.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 488mmx2440mm	74.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 535mmx2440mm	163.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 538mmx2440mm	164.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 543mmx2440mm	249.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 551mmx2440mm	84.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 556mmx2440mm	170.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 559mmx2440mm	85.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 616.2mmx2440mm	943.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 620mmx2440mm	94.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 640mmx2440mm	489.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 648mmx2440mm	99.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 670mmx2440mm	410.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 682mmx2440mm	195.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 696mmx2440mm	106.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 700mmx2440mm	428.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 710mmx2440mm	326.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 750mmx2440mm	5,165.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 772mmx2440mm	354.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 814mmx2440mm	124.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 822mmx2440mm	503.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 830mmx2440mm	3,302.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 842mmx2440mm	773.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 876.9mmx2440mm	268.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 877mmx2440mm	134.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 896mmx2440mm	137.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 930mmx2440mm	284.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 950mmx2440mm	1,744.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 958mmx2440mm	439.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 978mmx2440mm	140.3 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1220mmx732mm	4,256.9 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1320mmx732mm	56.8 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1490mmx732mm	547.3 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1530mmx732mm	65.9 kg

LCA Metadata (continued)

CLT Full Panel 1220mmx2440mm: CLT Half Panel 1610mmx732mm	517.4 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1990mmx732mm	85.7 kg
CLT Timber	201,344.7 kg
CLT Window Ope Center 910mm: CLT Window Ope Center 910mm	11,589.9 kg
CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm	1,617.2 kg
CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus ...	1,208.3 kg
Cross Laminated Timber CLT	4,582.3 kg
Cross Laminated Timber Mass 100mm	239.0 kg
Cross Laminated Timber Mass 188mm	2,241.5 kg
Cross Laminated Timber Mass 300	118,945.6 kg

Used in the following Tally entries:
Cross laminated timber (CrossLam / CLT)

Description:
PROXIED by LVL

Life Cycle Inventory:
43% PNW
57% SE
Proxied by LVL

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
US: Laminated veneer lumber, at plant, US PNW USLCI/PE (2009)
US: Laminated veneer lumber, at plant, US SE USLCI/PE (2009)

Domestic softwood, US — 4,252.5 kg

Used in the following Revit families:

CLT Door Ope 900mm: CLT Door Ope 900mm	1,973.6 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope Adaptable: Door ope Pa...	1,973.6 kg
IntSgl (7): 1010 x 2110mm	74.4 kg
IntSgl (7): 810 x 2110mm	128.8 kg
IntSgl (7): 910 x 2110mm	102.2 kg

Used in the following Tally entries:
Domestic softwood

Description:
Dimensional lumber, sawn, planed, dried and cut for standard framing or planking

Life Cycle Inventory:
38% PNW
62% SE
Dimensional lumber

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Surfaced dried lumber, at planer mill, PNW USLCI/PE (2009)
US: Surfaced dried lumber, at planer mill, SE USLCI/PE (2009)

Door frame, wood, no door — 279.1 kg

Used in the following Revit families:

IntSgl (7): 1010 x 2110mm	68.0 kg
IntSgl (7): 810 x 2110mm	117.7 kg
IntSgl (7): 910 x 2110mm	93.4 kg

Used in the following Tally entries:
Door frame, wood

Description:
Wood door frame

Life Cycle Inventory:
Dimensional lumber

Manufacturing Scope:
Cradle to gate, excludes hardware, jamnb, casing, sealant

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
DE: Wooden frame (EN15804 A1-A3) PE (2012)

Door, interior, wood, MDF Core, flush — 17,316.4 kg

Used in the following Revit families:

CLT Door Ope 900mm: CLT Door Ope 900mm	7,689.4 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope Adaptable: Door ope Pa...	7,689.4 kg
IntSgl (7): 1010 x 2110mm	523.0 kg
IntSgl (7): 810 x 2110mm	754.9 kg
IntSgl (7): 910 x 2110mm	659.7 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Interior flush wood door with MDF core

Life Cycle Inventory:
12.2 kg/m² Wood, 0.052 m3/m3 MDF

Manufacturing Scope:
Cradle to gate, excludes assembly, frame, hardware, and adhesives

End of Life Scope:
14.5% wood products recovered (credited as avoided burden)
22% wood products incinerated with energy recovery
63.5% wood products landfilled (wood product waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)
DE: Wood fibre board PE (2012)

Flooring, bamboo plank — 310,724.2 kg

Used in the following Revit families:

Bamboo LVB	3,740.6 kg
Corner Balcony Panel SE-NE 732mmx120mm: Corner Balcony Panel SE-NE ...	192.5 kg
Corner Balcony Panel SW-NW 732mm height: Corner Balcony Panel SW-NW...	313.1 kg
Corner Panel NE Corner 128mm: Corner Panel NE Corner 128mm	326.6 kg
Door ope Panel 2440mmx1220mm w-900x2110 No Door: Door ope Panel 24...	4,347.9 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope Adaptable: Door ope Pa...	2,736.0 kg
Generic Bamboo Mass 100	195.1 kg
Generic Bamboo Mass 188mm	1,829.8 kg
Generic Bamboo Mass 300	97,176.2 kg
Half Panel for Balcony 732mmx1220mm Adaptable: Half Panel for Balco...	1,048.1 kg
Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx7...	7.5 kg
Half Panel Single 230mm Width: Half Panel Single 100mm Width	1.5 kg
Half Panel Single 230mm Width: Half Panel Single 270mm Width	22.4 kg
Half Panel Single 230mm Width: Half Panel Single 310mm Width	3.0 kg
Half Panel Single 230mm Width: Half Panel Single 390mm Width	26.0 kg
LVB Bamboo Floor	164,371.7 kg
LVB Panel Full Size: LVB Panel 1000mm Width	88.4 kg
LVB Panel Full Size: LVB Panel 1014mm Width	238.3 kg
LVB Panel Full Size: LVB Panel 1022mm Width	89.9 kg
LVB Panel Full Size: LVB Panel 1036mm Width	30.3 kg
LVB Panel Full Size: LVB Panel 1058mm Width	30.8 kg
LVB Panel Full Size: LVB Panel 1078mm Width	31.3 kg
LVB Panel Full Size: LVB Panel 1100mm Width	954.0 kg
LVB Panel Full Size: LVB Panel 1130mm Width	130.0 kg
LVB Panel Full Size: LVB Panel 1145mm Width	131.4 kg
LVB Panel Full Size: LVB Panel 1152mm Width	462.3 kg
LVB Panel Full Size: LVB Panel 1160mm Width	199.2 kg
LVB Panel Full Size: LVB Panel 1192mm Width	135.8 kg
LVB Panel Full Size: LVB Panel 520mm Width	17.8 kg
LVB Panel Full Size: LVB Panel 538mm Width	37.3 kg
LVB Panel Full Size: LVB Panel 554mm Width	38.0 kg
LVB Panel Full Size: LVB Panel 616.2mm Width	204.7 kg
LVB Panel Full Size: LVB Panel 616mm Width	20.5 kg
LVB Panel Full Size: LVB Panel 620mm Width	20.6 kg
LVB Panel Full Size: LVB Panel 630mm Width	166.3 kg
LVB Panel Full Size: LVB Panel 662mm Width	43.1 kg
LVB Panel Full Size: LVB Panel 666mm Width	64.9 kg
LVB Panel Full Size: LVB Panel 670mm Width	86.9 kg
LVB Panel Full Size: LVB Panel 682mm Width	44.0 kg
LVB Panel Full Size: LVB Panel 690mm Width	66.6 kg
LVB Panel Full Size: LVB Panel 698mm Width	89.5 kg
LVB Panel Full Size: LVB Panel 702mm Width	22.5 kg

LCA Metadata (continued)

LVB Panel Full Size: LVB Panel 710mm Width	90.7 kg
LVB Panel Full Size: LVB Panel 712mm Width	45.4 kg
LVB Panel Full Size: LVB Panel 722mm Width	321.2 kg
LVB Panel Full Size: LVB Panel 730mm Width	23.1 kg
LVB Panel Full Size: LVB Panel 732mm Width	23.2 kg
LVB Panel Full Size: LVB Panel 734mm Width	232.3 kg
LVB Panel Full Size: LVB Panel 750mm Width	1,085.7 kg
LVB Panel Full Size: LVB Panel 760mm Width	47.7 kg
LVB Panel Full Size: LVB Panel 770mm Width	48.1 kg
LVB Panel Full Size: LVB Panel 772mm Width	144.7 kg
LVB Panel Full Size: LVB Panel 776mm Width	72.6 kg
LVB Panel Full Size: LVB Panel 803mm Width	74.5 kg
LVB Panel Full Size: LVB Panel 818mm Width	151.2 kg
LVB Panel Full Size: LVB Panel 821mm Width	227.4 kg
LVB Panel Full Size: LVB Panel 826mm Width	76.1 kg
LVB Panel Full Size: LVB Panel 829mm Width	50.9 kg
LVB Panel Full Size: LVB Panel 830mm Width	1,044.5 kg
LVB Panel Full Size: LVB Panel 832mm Width	102.1 kg
LVB Panel Full Size: LVB Panel 836mm Width	76.8 kg
LVB Panel Full Size: LVB Panel 842mm Width	309.1 kg
LVB Panel Full Size: LVB Panel 876.9mm Width	26.6 kg
LVB Panel Full Size: LVB Panel 877mm Width	26.6 kg
LVB Panel Full Size: LVB Panel 891mm Width	80.7 kg
LVB Panel Full Size: LVB Panel 900mm Width	54.2 kg
LVB Panel Full Size: LVB Panel 922mm Width	27.6 kg
LVB Panel Full Size: LVB Panel 930mm Width	55.6 kg
LVB Panel Full Size: LVB Panel 950mm Width	452.6 kg
LVB Panel Full Size: LVB Panel 976mm Width	28.9 kg
LVB Panel Full Size: LVB Panel 978mm Width	28.9 kg
LVB Panel Full Size: LVB Panel Full Size	22,566.6 kg
LVB Panel Full Size: LVB Panel Full Size 1212	172.1 kg
LVB Panel Full Size: LVB Panel Full Size 1216	34.5 kg
LVB Window Ope Center 910mm: LVB Window Ope Center 910mm	2,465.1 kg
Quad Corner Mullion: Quad Mullion Bamboo	43.2 kg
Rectangular Mullion: 50 x 120mm Bamboo	53.7 kg
Rectangular Mullion: 50 x 150mm Bamboo	742.0 kg
Single Box 230mmx2440mm: Single Box 120mmx2440mm	15.7 kg
Single Box 230mmx2440mm: Single Box 122mmx2440mm	5.3 kg
Single Box 230mmx2440mm: Single Box 132mmx2440mm	11.1 kg
Single Box 230mmx2440mm: Single Box 147mmx2440mm	5.9 kg
Single Box 230mmx2440mm: Single Box 151mmx2440mm	23.9 kg
Single Box 230mmx2440mm: Single Box 160mmx2440mm	6.2 kg
Single Box 230mmx2440mm: Single Box 163.2mmx2440mm	18.8 kg
Single Box 230mmx2440mm: Single Box 191mmx2440mm	41.5 kg
Single Box 230mmx2440mm: Single Box 214mmx2440mm	156.4 kg
Single Box 230mmx2440mm: Single Box 221mmx2440mm	30.5 kg
Single Box 230mmx2440mm: Single Box 222mmx2440mm	7.6 kg
Single Box 230mmx2440mm: Single Box 223.1mmx2440mm	23.0 kg
Single Box 230mmx2440mm: Single Box 228mmx2440mm	23.3 kg
Single Box 230mmx2440mm: Single Box 230mmx2440mm	31.3 kg
Single Box 230mmx2440mm: Single Box 231mmx2440mm	31.4 kg
Single Box 230mmx2440mm: Single Box 241mmx2440mm	24.2 kg
Single Box 230mmx2440mm: Single Box 248mmx2440mm	8.2 kg
Single Box 230mmx2440mm: Single Box 251mmx2440mm	33.3 kg
Single Box 230mmx2440mm: Single Box 255mmx2440mm	25.2 kg
Single Box 230mmx2440mm: Single Box 259mmx2440mm	8.5 kg
Single Box 230mmx2440mm: Single Box 260mmx2440mm	34.1 kg
Single Box 230mmx2440mm: Single Box 264mmx2440mm	25.9 kg
Single Box 230mmx2440mm: Single Box 270mmx2440mm	8.8 kg
Single Box 230mmx2440mm: Single Box 272mmx2440mm	35.2 kg
Single Box 230mmx2440mm: Single Box 282mmx2440mm	9.0 kg
Single Box 230mmx2440mm: Single Box 310mmx2440mm	145.5 kg
Single Box 230mmx2440mm: Single Box 320mmx2440mm	307.9 kg
Single Box 230mmx2440mm: Single Box 322mmx2440mm	10.0 kg
Single Box 230mmx2440mm: Single Box 327mmx2440mm	10.1 kg
Single Box 230mmx2440mm: Single Box 330.2mmx2440mm	81.4 kg
Single Box 230mmx2440mm: Single Box 331mmx2440mm	142.7 kg
Single Box 230mmx2440mm: Single Box 334mmx2440mm	102.6 kg
Single Box 230mmx2440mm: Single Box 342mmx2440mm	146.3 kg
Single Box 230mmx2440mm: Single Box 355mmx2440mm	43.0 kg
Single Box 230mmx2440mm: Single Box 358mmx2440mm	43.3 kg
Single Box 230mmx2440mm: Single Box 432mmx2440mm	25.1 kg
Single Box 230mmx2440mm: Single Box 72mmx2440mm	12.4 kg
Window Ope Offset 910mm: Window Ope offset 910mm	1,993.3 kg
Window Ope Offset Half Window: Window Ope Offset Half Window	127.6 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Bamboo plank flooring

Life Cycle Inventory:
90% Bamboo, 10% phenol formaldehyde

Manufacturing Scope:
Cradle to gate for raw material only, includes transportation from China and estimate for material processing neglects materials for installation

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
CN: Bamboo (estimation) PE (2012)
GLO: Bulk commodity carrier PE (2012)
US: Heavy fuel oil at refinery (0.3wt.% S) PE (2010)
CN: Electricity grid mix PE (2010)
DE: Phenol formaldehyde resin PE (2012)

Glazing, triple, insulated (argon), low-E — 9,622.0 kg

Used in the following Revit families:
System Panel: Glazed — 9,622.0 kg

Used in the following Tally entries:
Glazing, triple pane IGU

Description:
Glazing, triple, insulated (argon filled), 1/8" float glass, low-E, inclusive of argon gas fill, sealant, and spacers

Life Cycle Inventory:
32.4 kg/m² glass
Argon filled, 0.15 kg/m² low-e coating

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Insulation glass compound (3 panes) PE (2012)

Hardware, stainless steel — 9.1 kg

Used in the following Revit families:

CLT Door Ope 900mm: CLT Door Ope 900mm	0.6 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope Adaptable: Door ope Pan...	0.6 kg
IntSgl (7): 1010 x 2110mm	2.1 kg
IntSgl (7): 810 x 2110mm	3.1 kg
IntSgl (7): 910 x 2110mm	2.7 kg

Used in the following Tally entries:
Stainless steel, hardware

Description:
Finished, cast stainless steel entry applicable for door, window or other accessory hardware

Life Cycle Inventory:
Stainless steel

Manufacturing Scope:
Cradle to gate

End of Life Scope:
98% recovered (product has 58.1% scrap input while remainder is processed and credited as avoided burden)
2% landfilled (inert material)

Entry Source:
RER: Stainless steel Quarto plate (304) Eurofer (2008)
DE: Steel cast part machining PE (2012)
US: Electricity grid mix PE (2010)
RER: Stainless steel flat product (304) - value of scrap Eurofer (2008)

LCA Metadata (continued)

Interior grade plywood, US	1,023.1 kg
Used in the following Revit families:	
Stair	1,023.1 kg
Used in the following Tally entries:	
Flooring, engineered wood plank	
Description:	
Plywood, unfinished	
Life Cycle Inventory:	
33% PNW	
67% SE	
Plywood	
Proxied by exterior grade plywood	
Manufacturing Scope:	
Cradle to gate	
End of Life Scope:	
14.5% recovered (credited as avoided burden)	
22% incinerated with energy recovery	
63.5% landfilled (untreated wood waste)	
Entry Source:	
US: Plywood, at plywood plant, PNW USLCI/PE (2009)	
US: Plywood, at plywood plant, SE USLCI/PE (2009)	

None	0.0 kg
Used in the following Revit families:	
Bamboo LVB	0.0 kg
CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel	0.0 kg
CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel	0.0 kg
CLT Corner Panel: CLT Corner Panel Full Height NE-SE	0.0 kg
CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door	0.0 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	0.0 kg
CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1...	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1006mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1014mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1022mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1058mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1078mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1092mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1100mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1107mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1115mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1123mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1127mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1130mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1145mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1160mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1192mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1204mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1212mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1219mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1220mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1228mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1232mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1260mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1274mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1284mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1286mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1305mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1334mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1340mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1352mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1375mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1383mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1411mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1434mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1435mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1442mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1448mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1455mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 151mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1531mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1539mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1542.8mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1578mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1652mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1702mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1738mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1740mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1756mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1764mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1800mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1850mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1852mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1860mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1876mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1878mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm 2	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1910mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1932mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1941mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1942mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1944mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1946mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1950mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1954mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1973mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1988mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1991mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2002.2mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2033mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2038mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2048mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2049mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2050mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2056mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2064mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2111mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2196mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2372mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2380mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2440mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2484mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2492mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2760mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 290mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 350mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 462mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 488mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 535mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 538mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 543mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 551mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 556mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 559mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 616.2mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 620mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 640mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 648mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 670mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 682mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 696mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 700mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 710mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 750mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 772mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 814mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 822mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 830mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 842mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 876.9mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 877mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 896mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 930mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 950mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 958mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 978mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1220mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1320mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1490mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1530mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1610mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1990mmx732mm	0.0 kg
CLT Timber	0.0 kg
CLT Window Ope Center 910mm: CLT Window Ope Center 910mm	0.0 kg
CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm	0.0 kg

LCA Metadata (continued)

CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus ...	0.0 kg
Corner Balcony Panel SE-NE 732mmx120mm: Corner Balcony Panel SE-NE ...	0.0 kg
Corner Balcony Panel SW-NW 732mm height: Corner Balcony Panel SW-NW...	0.0 kg
Corner Panel NE Corner 128mm: Corner Panel NE Corner 128mm	0.0 kg
Cross Laminated Timber CLT	0.0 kg
Cross Laminated Timber Mass 100mm	0.0 kg
Cross Laminated Timber Mass 188mm	0.0 kg
Cross Laminated Timber Mass 300	0.0 kg
Door ope Panel 2440mmx1220mm w-900x2110 No Door: Door ope Panel 244...	0.0 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope Adaptable: Door ope Pan...	0.0 kg
Generic Bamboo Mass 100	0.0 kg
Generic Bamboo Mass 188mm	0.0 kg
Generic Bamboo Mass 300	0.0 kg
Half Panel for Balcony 732mmx1220mm Adaptable: Half Panel for Balco...	0.0 kg
Half Panel for Balcony 732mmx1220mm: Half Panel for Balcony 732mmx7...	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 100mm Width	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 270mm Width	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 310mm Width	0.0 kg
Half Panel Single 230mm Width: Half Panel Single 390mm Width	0.0 kg
IntSgl (7): 1010 x 2110mm	0.0 kg
IntSgl (7): 810 x 2110mm	0.0 kg
IntSgl (7): 910 x 2110mm	0.0 kg
LVB Bamboo Floor	0.0 kg
LVB Panel Full Size: LVB Panel 1000mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1014mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1022mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1036mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1058mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1078mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1100mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1130mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1145mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1152mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1160mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 1192mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 520mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 538mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 554mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 616.2mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 616mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 620mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 630mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 662mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 666mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 670mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 682mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 690mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 698mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 702mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 710mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 712mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 722mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 730mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 732mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 734mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 750mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 760mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 770mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 772mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 776mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 803mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 818mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 821mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 826mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 829mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 830mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 832mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 836mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 842mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 876.9mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 877mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 891mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 900mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 922mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 930mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 950mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 976mm Width	0.0 kg
LVB Panel Full Size: LVB Panel 978mm Width	0.0 kg
LVB Panel Full Size: LVB Panel Full Size	0.0 kg
LVB Panel Full Size: LVB Panel Full Size 1212	0.0 kg
LVB Panel Full Size: LVB Panel Full Size 1216	0.0 kg
LVB Window Ope Center 910mm: LVB Window Ope Center 910mm	0.0 kg
Single Box 230mmx2440mm: Single Box 120mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 122mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 132mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 147mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 151mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 160mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 163.2mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 191mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 214mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 221mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 222mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 223.1mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 228mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 230mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 231mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 241mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 248mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 251mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 255mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 259mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 260mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 264mmx2440mm	0.0 kg
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Single Box 230mmx2440mm: Single Box 320mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 322mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 327mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 330.2mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 331mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 334mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 342mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 355mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 358mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 432mmx2440mm	0.0 kg
Single Box 230mmx2440mm: Single Box 72mmx2440mm	0.0 kg
Stair	0.0 kg
Window Ope Offset 910mm: Window Ope offset 910mm	0.0 kg
Window Ope Offset Half Window: Window Ope Offset Half Window	0.0 kg

Used in the following Tally entries:
- Cross laminated timber (CrossLam / CLT)
- Domestic softwood
- Door, interior, wood, MDF core, flush
- Flooring, bamboo plank
- Flooring, engineered wood plank

Description:
This entry is a placeholder, for use in cases when there is "no" finish, or "no added material designated.

Manufacturing Scope:
NA

Entry Source:
None

Polyurethane floor finish, water-based 203.7 kg

Used in the following Revit families:

Quad Corner Mullion: Quad Mullion Bamboo	0.0 kg
Rectangular Mullion: 50 x 120mm Bamboo	0.0 kg
Rectangular Mullion: 50 x 150mm Bamboo	0.3 kg
Stair	203.3 kg

Used in the following Tally entries:
- Flooring, bamboo plank
- Flooring, engineered wood plank

Description:
Water-based polyurethane wood stain, inclusive of catalyst

Life Cycle Inventory:
97.7% stain (50% water, 35% polyurethane dispersions, 5% dipropylene glycol dimethyl ether, 5% tri-butoxyethyl phosphate, 5% dipropylene glycol methyl ether), 2.3% catalyst (75% polyfunctional aziridine, 25% 2-propoxyethanol)
24.5% NMVOC emissions during application

Manufacturing Scope:
Cradle to gate, including emissions during application

End of Life Scope:
26.7% solids to landfill (plastic waste)

LCA Metadata (continued)

Entry Source:
DE: Ethylene glycol butyl ether PE (2012)
US: Epichlorohydrin (by product calcium chloride, hydrochloric acid) PE (2012)
DE: Propylenglycolmonomethylether (Methoxypropanol) PGME PE (2012)
US: Tap water from groundwater PE (2012)
DE: Polyurethane (copolymer-component) (estimation from TPU adhesive) PE (2012)
US: Electricity grid mix PE (2010)

Powder coating, metal stock 90.2 kg

Used in the following Revit families:

1100mm	72.5 kg
Quad Corner Mullion: Quad Mullion 1	0.5 kg
Rectangular Mullion: 50 x 120mm	1.2 kg
Rectangular Mullion: 50 x 150mm	16.0 kg

Used in the following Tally entries:
Aluminum, extrusion

Description:
Powder coating, for metal stock

Manufacturing Scope:
Cradle to gate, including application

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Application top coat powder (aluminium) PE (2012)
DE: Coating powder (industry
outside
red) PE (2012)

Stainless steel, door hardware, lever lock, interior, residential 2,302.9 kg

Used in the following Revit families:

CLT Door Ope 900mm: CLT Door Ope 900mm	1,416.3 kg
Door ope Panel 2440mmx1220mm w-900x2110 ope Adaptable: Door ope Pan..	708.2 kg
IntSgl (7): 1010 x 2110mm	48.2 kg
IntSgl (7): 810 x 2110mm	69.5 kg
IntSgl (7): 910 x 2110mm	60.8 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Stainless steel door fitting (hinges and lockset) for use on residential interior door assemblies.

Life Cycle Inventory:
Door hinges 0.622 kg/part, Battalion Lever Lockset, Light Duty, Privacy 0.70 kg/part

Manufacturing Scope:
Cradle to gate, including disposal of packaging.

End of Life Scope:
90% collection rate
remaining 10% deposited in the LCA model without recycling
material recycling efficiency dependant on the metal (89% steel, 90.2% aluminum, stainless steel 83%, zinc 91%, brass 94%)
Plastic components incinerated resulting in credits for electricity and thermal energy

Entry Source:
DE: Fitting stainless steel - FSB (2009)

Urethane adhesive 190.2 kg

Used in the following Revit families:

Quad Corner Mullion: Quad Mullion Bamboo	5.1 kg
Rectangular Mullion: 50 x 120mm Bamboo	13.3 kg
Rectangular Mullion: 50 x 150mm Bamboo	171.8 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Urethane adhesive for use with flooring and wall coverings.

Life Cycle Inventory:
50% limestone, 13% lime, 30% polyurethane, 1.5% stearic acid, 5% Methylene bis(phenylisocyanate) (MDI)
1.3% NMVOC emissions

Manufacturing Scope:
Cradle to gate, plus emissions during application

End of Life Scope:
98.7% solids to landfill (plastic waste)

Entry Source:
US: Limestone flour (5mm) PE (2012)
DE: Polyurethane (copolymer-component) (estimation from TPU adhesive) PE (2012)
US: Lime (CaO) calcination PE (2012)
US: Methylene diisocyanate (MDI) PE (2012)
DE: Stearic acid PE (2012)
US: Electricity grid mix PE (2010)

Veneer, hardwood 307.1 kg

Used in the following Revit families:

Stair	307.1 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Hardwood veneer

Life Cycle Inventory:
43% PNW
57% SE
veneer

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% landfilled (biodegradable waste)

Entry Source:
US: Dry veneer, at plywood plant, PNW USLCI/PE (2009)
US: Dry veneer, at plywood plant, SE USLCI/PE (2009)

Stadthaus, Murray Grove

24mm thick 128mm LVB v's 128mm CLT

29/02/2016

tally™

Table of Contents

Report Summary

Created with Tally
Non-commercial Version 2014.06.17.01

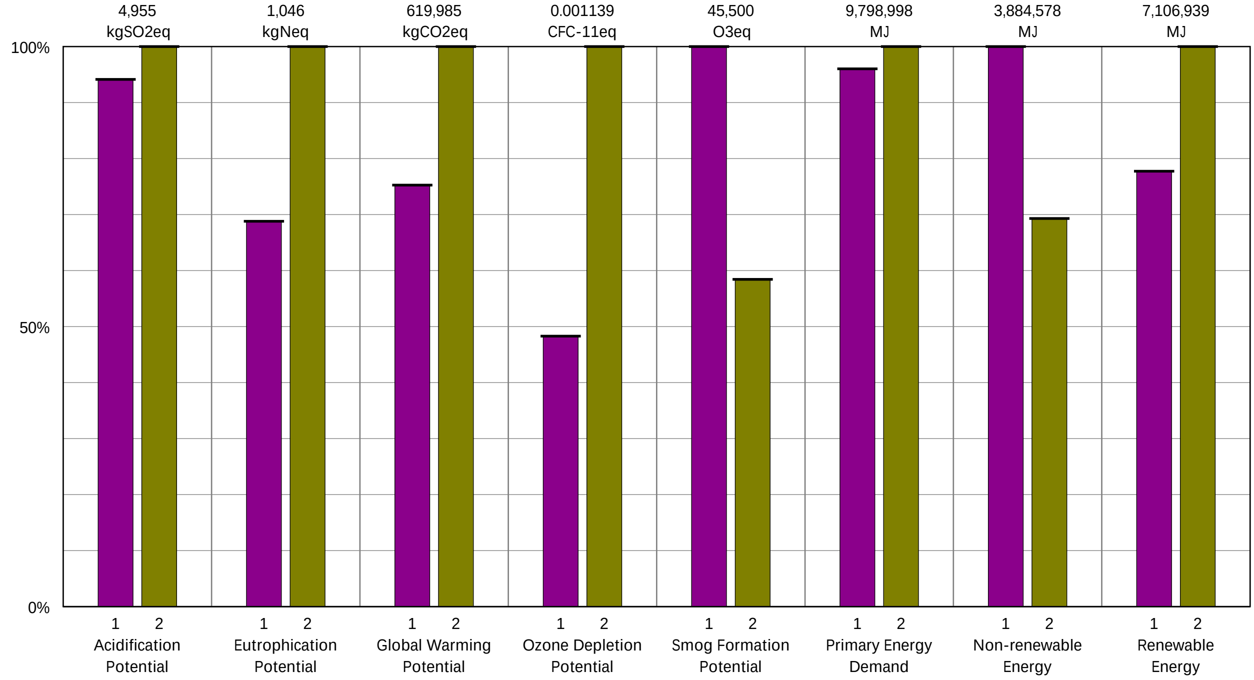
Author : Philip Kavanagh
Company : Dublin Institute of Technology
Date : 29/02/2016

Project : Stadthaus, Murray Grove
Location : London, England
Gross Area : 2782.998 m²
Building Life : 50

Scope : Cradle-to-Grave, exclusive of operational energy

Goal of Assessment :
To determine the global warming potential, through life cycle analysis, of laminated veneer bamboo diaphragm panel construction over the selection of cross laminated timber panels for use in mid to high rise residential accommodation.

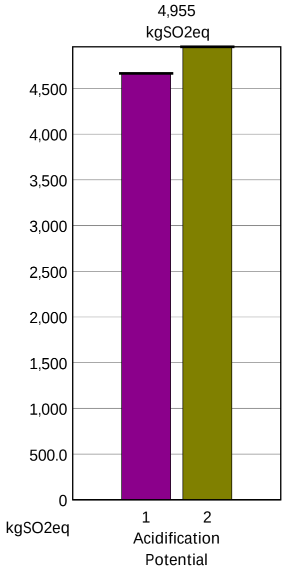
Object of Study
Design options set 'Option Set 1'
Bamboo LVB Hybrid Box (primary)
Cross Laminated Timber

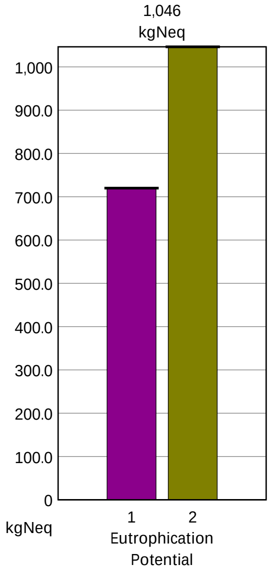


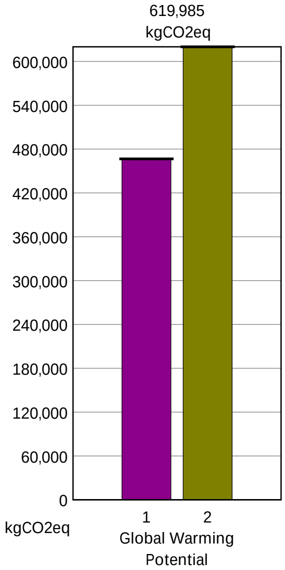
Legend

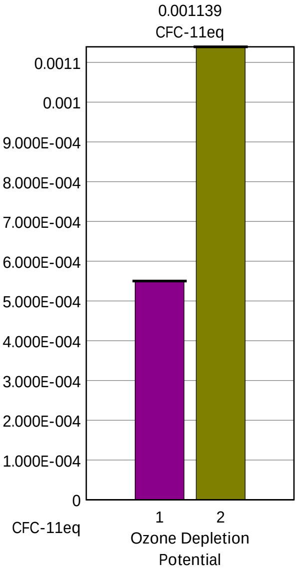
Design Options
Bamboo LVB Hybrid Box (primary)
Cross Laminated Timber

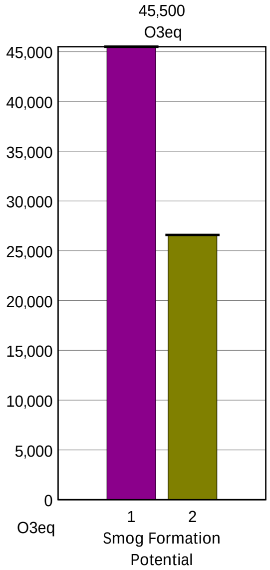
Report Summary (continued)

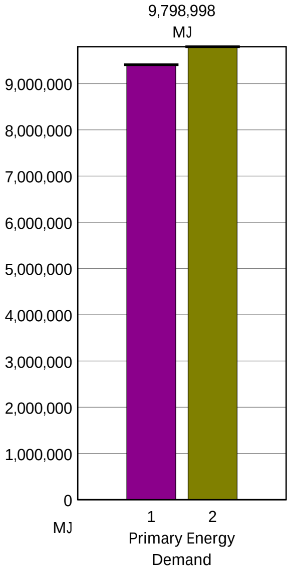


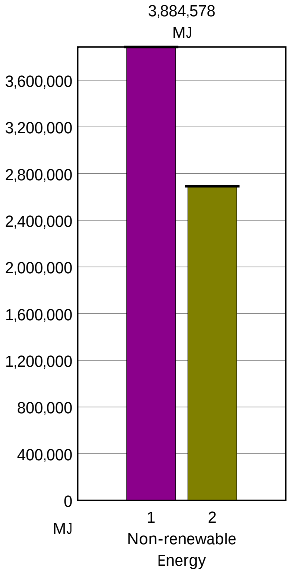


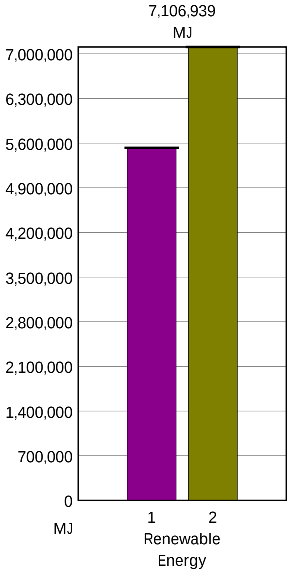










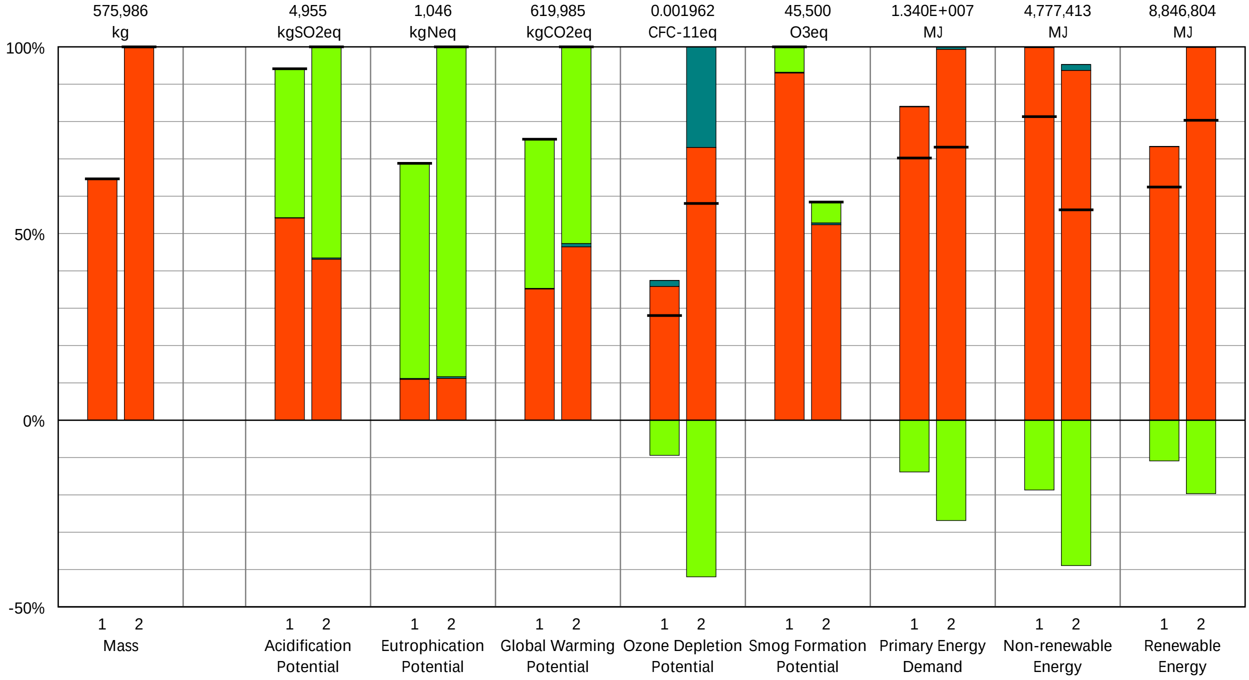


Legend

Design Options

- Bamboo LVB Hybrid Box (primary)
- Cross Laminated Timber

Results per Life Cycle Stage



Legend

Net value (impacts + credits)

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

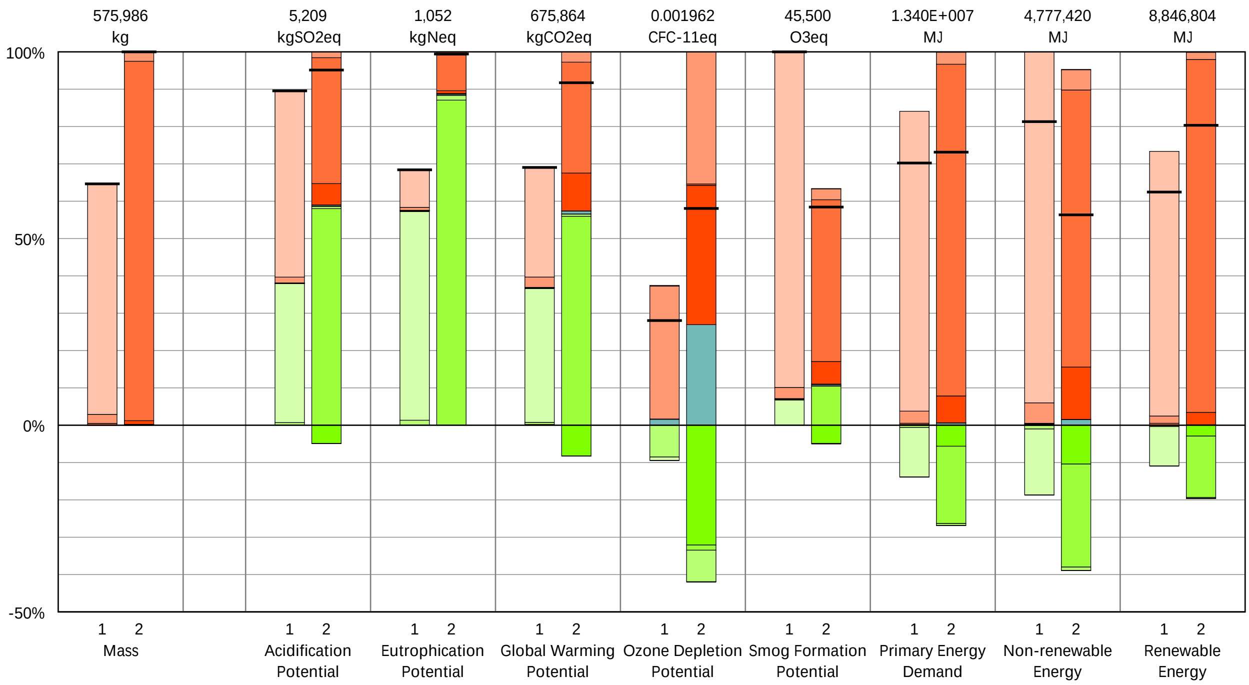
Life Cycle Stages

Manufacturing

Maintenance and Replacement

End of Life

Results per Life Cycle Stage, itemized by CSI Division



Legend

Net value (impacts + credits)

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Manufacturing

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

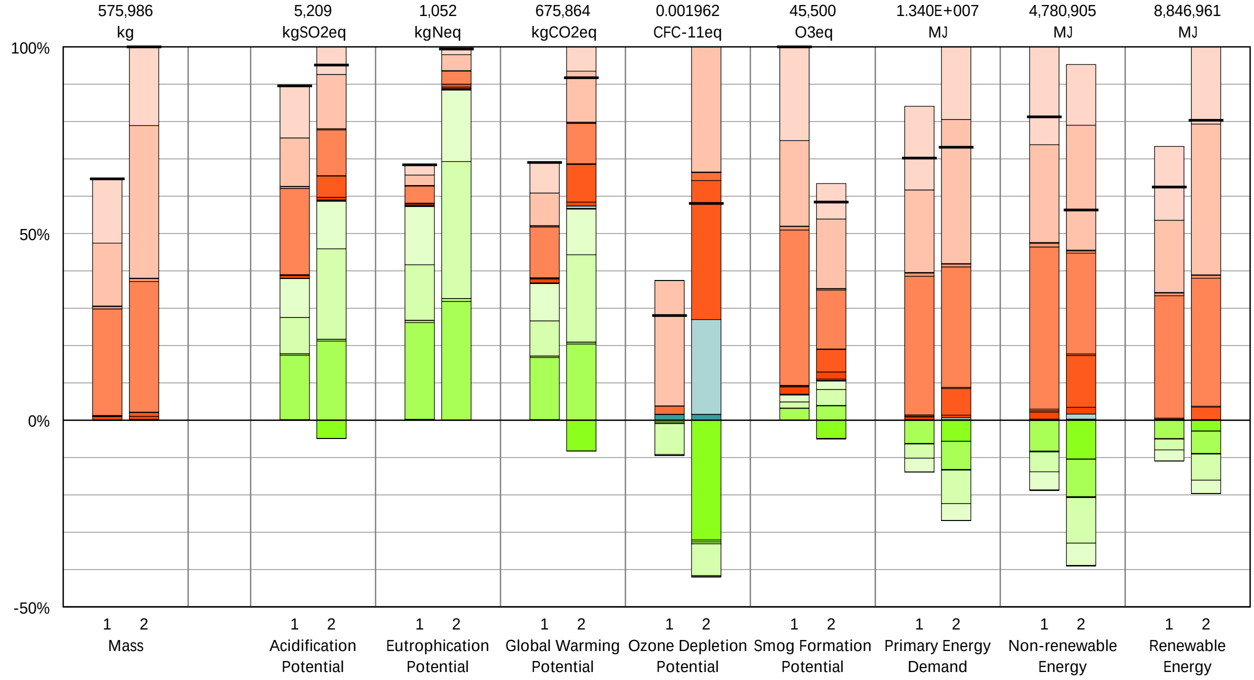
Maintenance and Replacement

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

End of Life

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

Results per Life Cycle Stage, itemized by Revit Category



Legend

Net value (impacts + credits)

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Manufacturing

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

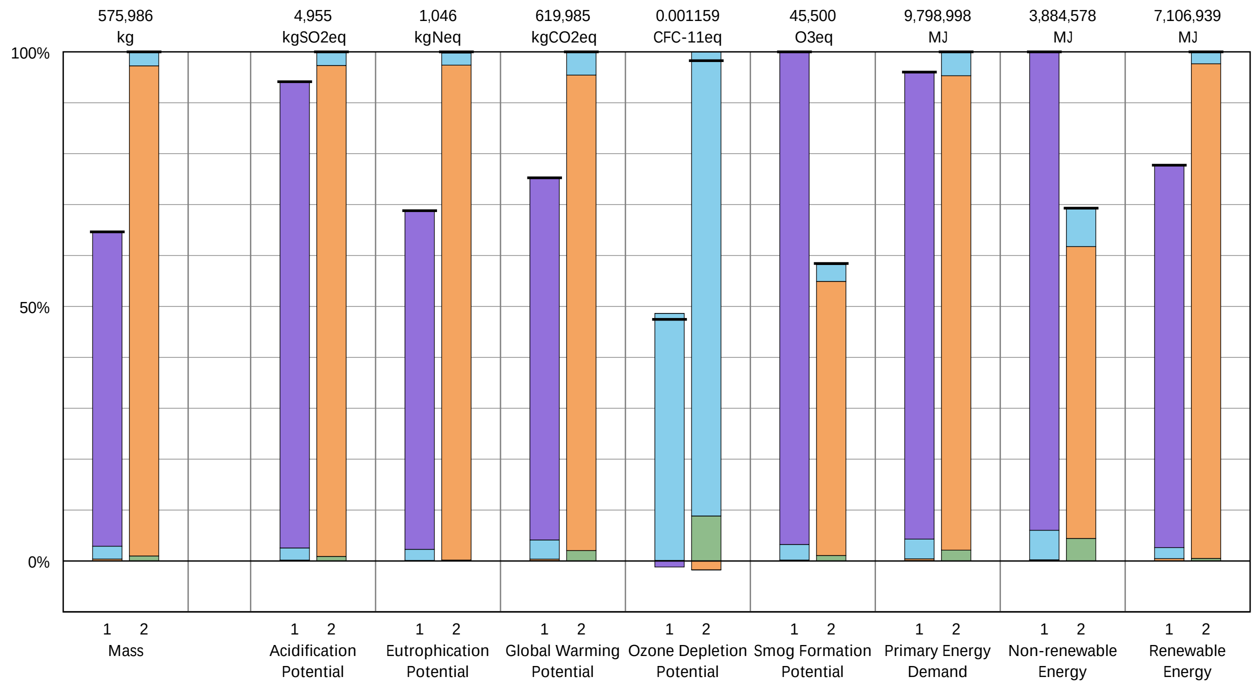
Maintenance and Replacement

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

End of Life

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per CSI Division



Legend

Design Options

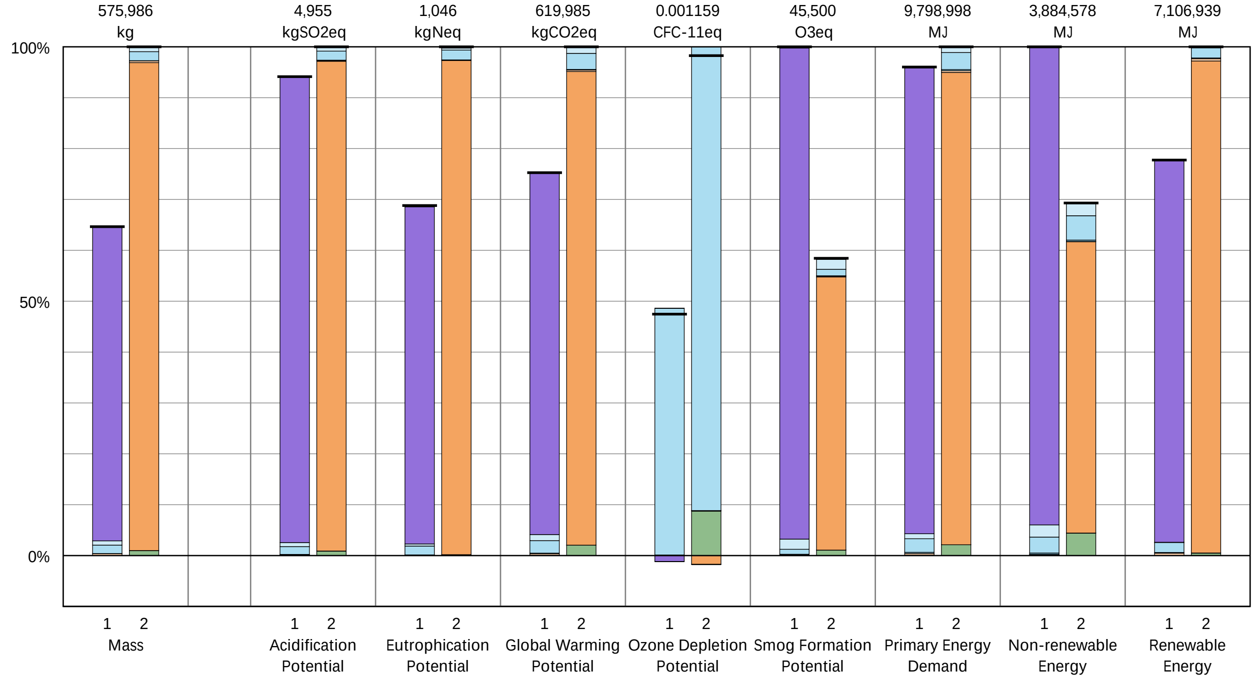
Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

CSI Divisions

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

Results per CSI Division, itemized by Tally Entry



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

05 - Metals

- Aluminum, extrusion
- Stainless steel, hardware

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam / CLT)
- Domestic softwood

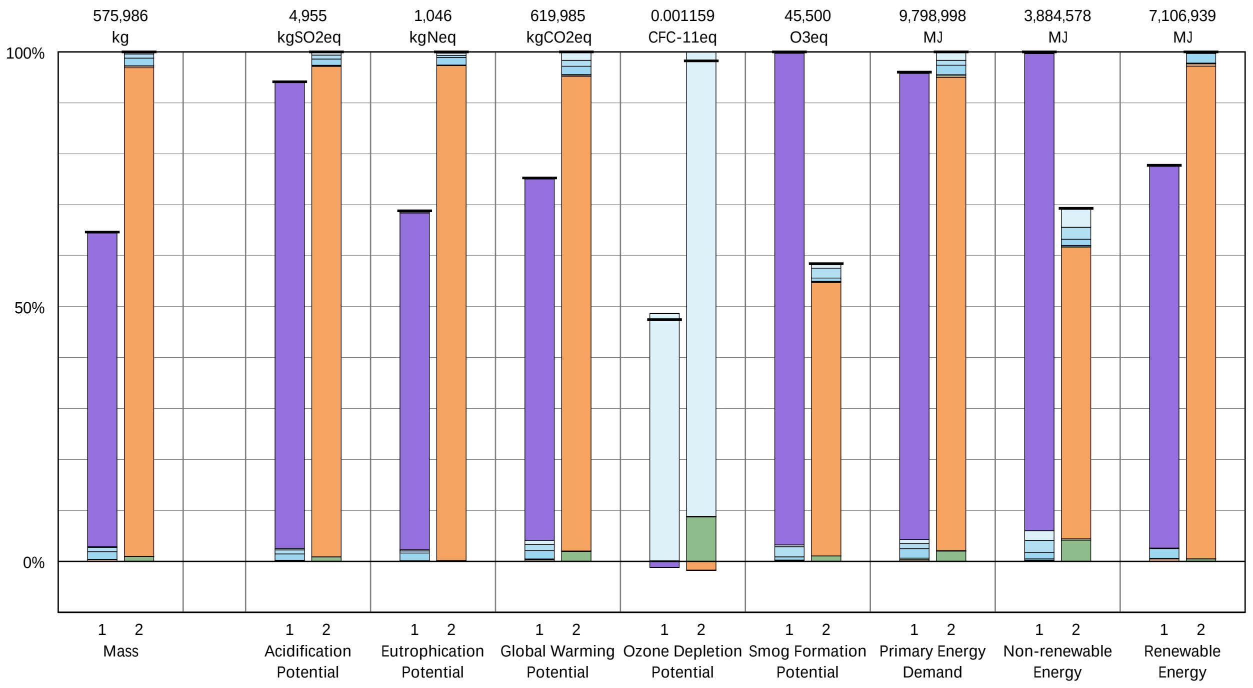
08 - Openings and Glazing

- Door frame, wood
- Door, interior, wood, MDF core, flush
- Glazing, triple pane IGU

09 - Finishes

- Flooring, bamboo plank
- Flooring, engineered wood plank

Results per CSI Division, itemized by Material



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

05 - Metals

- Aluminum, extruded
- Hardware, stainless steel
- Powder coating, metal stock

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam)
- Domestic softwood, US
- None

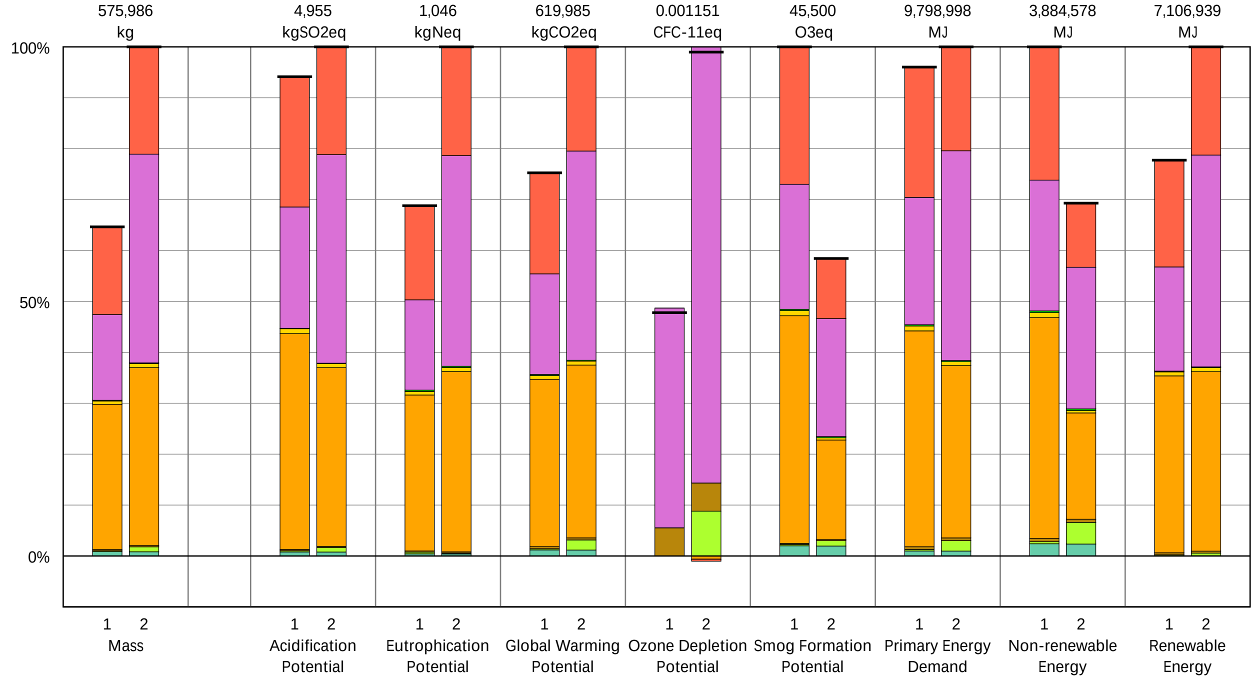
08 - Openings and Glazing

- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Glazing, triple, insulated (argon), low-E
- None
- Stainless steel, door hardware, lever lock, interior, residential

09 - Finishes

- Flooring, bamboo plank
- Interior grade plywood, US
- None
- Polyurethane floor finish, water-based
- Urethane adhesive
- Veneer, hardwood

Results per Revit Category



Legend

Design Options

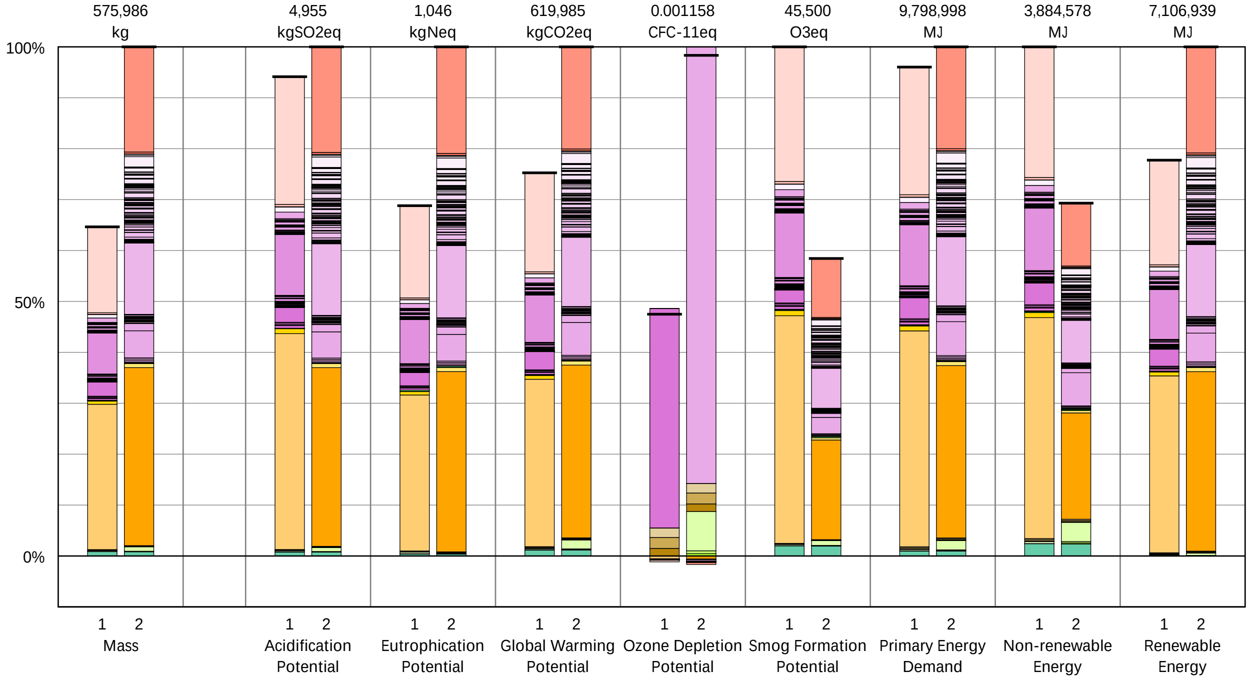
Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Revit Categories

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per Revit Category, itemized by Family



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- System Panel: Glazed

Curtain Wall Mullions

- Quad Corner Mullion: Quad Mullion 1
- Quad Corner Mullion: Quad Mullion Bamboo
- Rectangular Mullion: 50 x 120mm
- Rectangular Mullion: 50 x 120mm Bamboo
- Rectangular Mullion: 50 x 150mm
- Rectangular Mullion: 50 x 150mm Bamboo

Doors

- IntSgl (7): 1010 x 2110mm
- IntSgl (7): 810 x 2110mm
- IntSgl (7): 910 x 2110mm

Floors

- CLT Timber
- LVB Bamboo Floor

Roofs

- Bamboo LVB
- Cross Laminated Timber CLT

Stairs and Railings

- 1100mm
- Stair

Structure

- 24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel Single 100mm
- 24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel Single 270mm
- 24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel Single 310mm
- 24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel Single 390mm
- 24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Panel 732 x 1...
- 24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Panel 732 x 762
- 24mm LVB Corner Panel Adaptable 2440mm x Length x Length: 24mm LVB Corner Pa
- 24mm LVB Corner Panel Half Adaptable 2440mm x Length x Length: 24mm LVB Corne
- 24mm LVB Door Ope Panel 2440x1220x128 NO Door A: 24mm LVB Door Ope Panel 2440...
- 24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm LVB Door Op...
- 24mm LVB Level 8 Window 300 x 910mm Offset: 24mm LVB Level 8 Window 300 x 910...
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 120
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 122
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 132
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 147
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 151
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 160
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 163.2
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 191
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 214
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 221
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 222
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 223.1
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 228
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 230
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 231
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 241
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 248
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 251
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 255
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 259
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 260
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 264
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 270
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 272
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 282
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 310
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 320
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 322
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 330.2
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 331
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 334
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 342
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 355
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 358
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 432
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 72
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1000mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1014mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1022mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1036mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1058mm Panel

Results per Revit Category, itemized by Family (continued)

Legend (continued)

24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1078mm Pane
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1100mm Pane
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1130mm Pane
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1145mm Pane
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1152mm Pane
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1160mm Pane
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1192mm Pane
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1212mm Pane
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1216mm Pane
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1220mm Pane
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x520mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x538mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x554mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616.2mm Pan
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x620mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x630mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x662mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x666mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x670mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x682mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x690mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x698mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x702mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x710mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x712mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x722mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x730mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x732mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x734mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x750mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x760mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x770mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x772mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x776mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x803mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x818mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x821mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x826mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x829mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x830mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x832mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x836mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x842mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x876.9mm Pan
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x877mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x891mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x900mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x922mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x930mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x950mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x976mm Panel
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x978mm Panel
24mm Window 910mm Center 1220x2440mm: 24mm Window 910mm Center 1220x2 m
CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel
CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel
CLT Corner Panel: CLT Corner Panel Full Height NE-SE
CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door
CLT Door Ope 900mm: CLT Door Ope 900mm
CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1820mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1006mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1014mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1022mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1058mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1078mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1092mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1100mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1107mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1115mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1123mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1127mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1130mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1145mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1160mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1192mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1204mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1212mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1219mmx2440mm
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CLT Full Panel 1220mmx2440mm: CLT Full Panel 1274mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1284mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1286mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1305mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1334mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1340mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1352mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1375mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1383mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1411mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1434mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1435mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1442mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1448mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1455mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 151mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1531mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1539mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1542.8mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1578mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1652mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1702mmx2440mm
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CLT Full Panel 1220mmx2440mm: CLT Full Panel 1740mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1756mmx2440mm
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CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1932mmx2440mm
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CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2033mmx2440mm
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CLT Full Panel 1220mmx2440mm: CLT Full Panel 2050mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2056mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2064mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2111mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2196mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2372mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2380mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2440mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2484mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2492mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2760mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 290mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 350mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 462mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 488mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 535mmx2440mm
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CLT Full Panel 1220mmx2440mm: CLT Full Panel 556mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 559mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 616.2mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 620mmx2440mm
CLT Full Panel 1220mmx2440mm: CLT Full Panel 640mmx2440mm

Results per Revit Category, itemized by Family (continued)

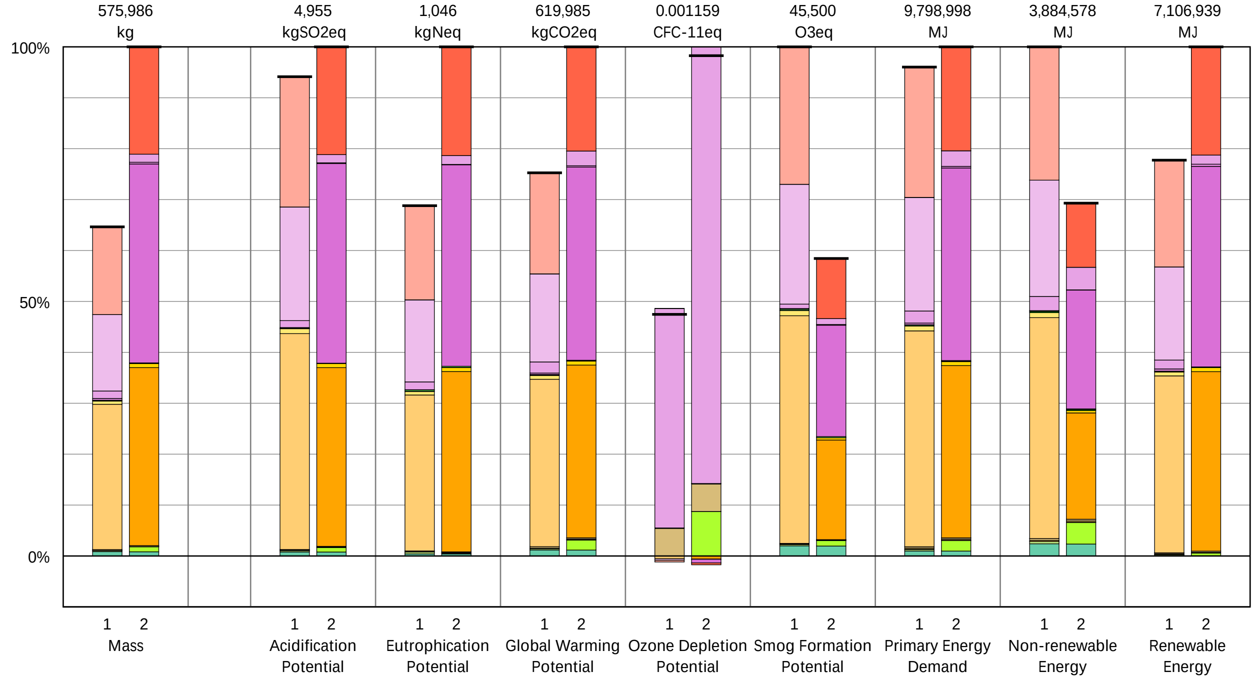
Legend (continued)

- CLT Full Panel 1220mmx2440mm: CLT Full Panel 648mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 670mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 682mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 696mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 700mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 710mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 750mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 772mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 814mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 822mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 830mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 842mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 876.9mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 877mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 896mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 930mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 950mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 958mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 978mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1220mmx732mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1320mmx732mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1490mmx732mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1530mmx732mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1610mmx732mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1990mmx732mm
- CLT Window Ope Center 910mm: CLT Window Ope Center 910mm
- CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm
- CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus Half 1260mm
- Window 910mm Offset 1220 x 2440mm: 24mm LVB Window 910mm Offset 1220 x 2440mm

Walls

- Cross Laminated Timber Mass 100mm
- Cross Laminated Timber Mass 188mm
- Cross Laminated Timber Mass 300
- Generic Bamboo Mass 100
- Generic Bamboo Mass 188mm
- Generic Bamboo Mass 300

Results per Revit Category, itemized by Tally Entry



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- Glazing, triple pane IGU

Curtain Wall Mullions

- Aluminum, extrusion
- Flooring, bamboo plank

Doors

- Domestic softwood
- Door frame, wood
- Door, interior, wood, MDF core, flush
- Stainless steel, hardware

Floors

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Roofs

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Stairs and Railings

- Aluminum, extrusion
- Flooring, engineered wood plank

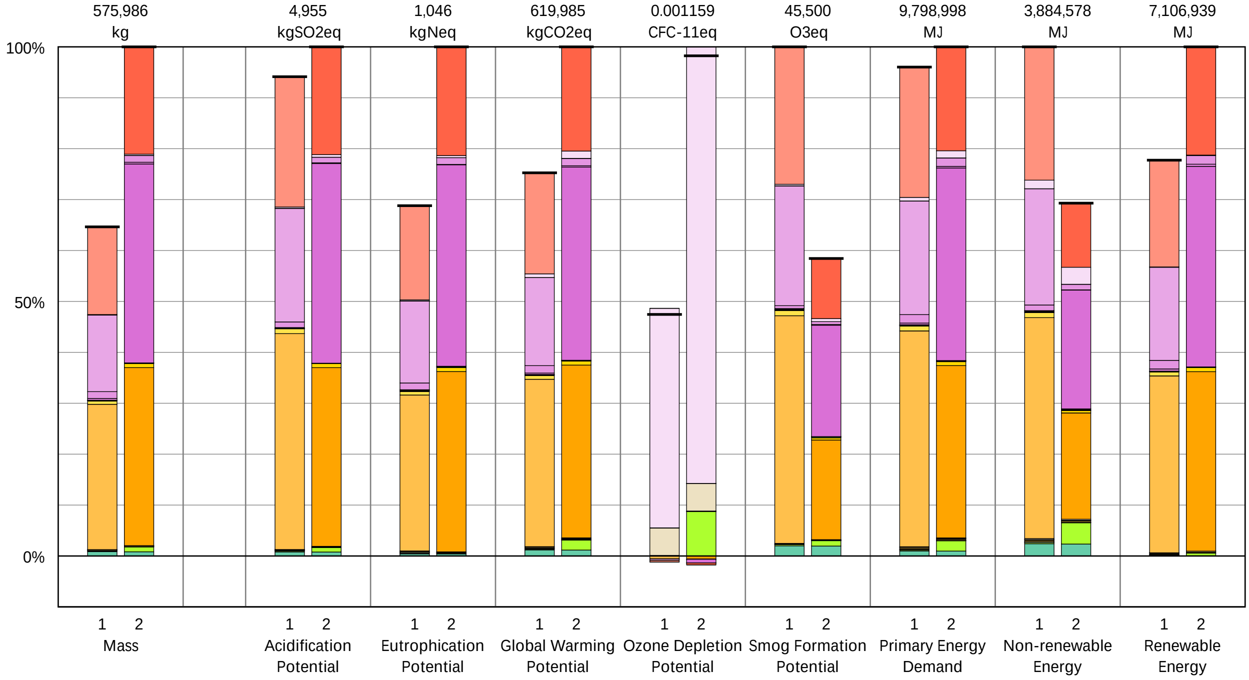
Structure

- Cross laminated timber (CrossLam / CLT)
- Domestic softwood
- Door, interior, wood, MDF core, flush
- Flooring, bamboo plank
- Stainless steel, hardware

Walls

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Results per Revit Category, itemized by Material



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Box (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- Glazing, triple, insulated (argon), low-E

Curtain Wall Mullions

- Aluminum, extruded
- Flooring, bamboo plank
- Polyurethane floor finish, water-based
- Powder coating, metal stock
- Urethane adhesive

Doors

- Domestic softwood, US
- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Hardware, stainless steel
- None
- Stainless steel, door hardware, lever lock, interior, residential

Floors

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Roofs

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Stairs and Railings

- Aluminum, extruded
- Interior grade plywood, US
- None
- Polyurethane floor finish, water-based
- Powder coating, metal stock
- Veneer, hardwood

Structure

- Cross laminated timber (CrossLam)
- Domestic softwood, US
- Door, interior, wood, MDF Core, flush
- Flooring, bamboo plank
- Hardware, stainless steel
- None
- Stainless steel, door hardware, lever lock, interior, residential

Walls

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Calculation Methodology

Studied objects

The LCA results in the report represent either an analysis of a single building, or a comparative analysis of two or more building design options. The single building may represent the complete architectural, structural, and finish systems of a building or a subset of those systems, and it may be used to compare the relative contributions of building systems to environmental impacts and for comparative study with one or more reference buildings. The comparison of design options may represent a full building in various stages of the design process, or they may represent multiple schemes of a full or partial building that are being compared to one another across a range of evaluation criteria.

Functional unit and reference flow

The functional unit of the analysis is the usable floor space of the building under study. For a design option comparison of a partial building, the functional unit is the complete set of building systems that performs a given function. The reference flow is the amount of material required to produce a building, or portion thereof, designed according to the given goal and scope of the assessment, over the full life of the building. If operational energy is included in the assessment the reference flow also includes the electrical and thermal energy consumed on site over the life of the building. It is the responsibility of the modeler to assure that reference buildings or design options are functionally equivalent in terms of scope, size, and relevant performance. The expected life of the building has a default value of 60 years and can be modified by the model author.

System boundaries and delimitations

The analysis accounts for the full cradle-to-grave life cycle of the design options studied, including material manufacturing, maintenance and replacement, and eventual end-of-life (disposal, incineration, and/or recycling), including the materials and energy used across all life cycle stages. Optionally, the operational energy of the building can be included within the scope.

Architectural materials and assemblies include all materials required for the product’s manufacturing and use (including hardware, sealants, adhesives, coatings, and finishing, etc.) up to a 1% cut-off factor by mass with the exception of known materials that have high environmental impacts at low levels. In these cases, a 1% cut-off was implemented by impact.

Manufacturing includes cradle-to-gate manufacturing wherever possible. This includes raw material extraction and processing, intermediate transportation, and final manufacturing and assembly. Due to data limitations, however, some manufacturing steps have been excluded, such as the material and energy requirements for assembling doors and windows. The manufacturing scope is listed for each entry, detailing any specific inclusions or exclusions that fall outside of the cradle-to-gate scope.

Transportation of upstream raw materials or intermediate products to final manufacturing is generally included in the GaBi datasets utilized within this tool. Transportation requirements between the manufacturer and installation of the product, and at the end-of-life of the product, are excluded from this study.

Infrastructure (buildings and machinery) required for the manufacturing and assembly of building materials, as well as packaging materials, are not included and are considered outside the scope of assessment.

Maintenance and replacement encompasses the replacement of materials in accordance with the expected service life. This includes the end-of-life treatment of the existing products and cradle-to-gate manufacturing of the replacement products. The service life is specified separately for each product.

Operational energy treatment is based on the anticipated energy consumed at the building site over the lifetime of the building. Each energy dataset includes relevant upstream impacts associated with extraction of energy resources (e.g., coal, crude oil), refining, combustion, transmission, losses, and other associated factors. US electricity generation datasets are based on subregions from US EPA's eGRID2012 database v1.0, but adapted to account for imports and exports into these regions. These consumption mixes - unique to the GaBi databases - provide a more accurate reflection of impacts associated with electricity consumption.

End-of-life treatment is based on average US construction and demolition waste treatment methods and rates. This includes the relevant material collection rates for recycling, processing requirements for recycled materials, incineration rates, and landfilling rates. Along with processing requirements, the recycling of materials is modeled using an avoided burden approach, where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material. Incineration of materials includes credit for average US energy recovery rates. The impacts associated with landfilling are based on average material properties, such as plastic waste, biodegradable waste, or inert material. Specific end-of-life scenarios are detailed for each entry.

Data source and quality

Tally utilizes a custom designed LCA database that combines material attributes, assembly details, and engineering and architectural specifications with environmental impact data resulting from the collaboration between KieranTimberlake and PE INTERNATIONAL. LCA modeling was conducted in GaBi 6 using GaBi databases and in accordance with GaBi database and modeling principles.

Geography and date: The data used are intended to represent the US and the year 2013. Where representative data were unavailable, proxy data were used. The datasets used, their geographic region, and year of reference are listed for each entry. An effort was made to choose proxy datasets that are technologically consistent with the relevant entry.

Uncertainty in results can stem from both the data used and the application of the data. Data quality is judged by its precision (measured, calculated, or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological). The LCI data sets from the GaBi LCI databases have been used in LCA models worldwide in industrial and scientific applications, both as internal and critically reviewed and published studies. The uncertainty introduced by the use of any proxy data is reduced by using technologically, geographically, and/or temporally similar data. It is the responsibility of the modeler to apply the predefined material entries appropriately to the building under study.

Tally methodology is consistent with LCA standards ISO 14040-14044.

Glossary of LCA Terminology

Environmental Impact Categories

The following list provides a description of environmental impact categories reported according to the TRACI 2.1 characterization scheme. References: [Bare 2010, EPA 2012, Guinée 2001]

Acidification Potential (AP) — kg SO2 eq

A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline, and the deterioration of building materials.

Eutrophication Potential (EP) — kg N eq

Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.

Global Warming Potential (GWP) — kg CO2 eq

A measure of greenhouse gas emissions, such as CO2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health, and material welfare.

Ozone Depletion Potential (ODP) — kg CFC-11 eq

A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants.

Smog Formation Potential (SFP) — kg O3 eq

Ground level ozone is created by various chemical reactions, which occur between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in sunlight. Human health effects can result in a variety of respiratory issues including increasing symptoms of bronchitis, asthma, and emphysema. Permanent lung damage may result from prolonged exposure to ozone. Ecological impacts include damage to various ecosystems and crop damage. The primary sources of ozone precursors are motor vehicles, electric power utilities, and industrial facilities.

Primary Energy Demand (PED) — MJ (lower heating value)

A measure of the total amount of primary energy extracted from the earth. PED is expressed in energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.) and energy demand from renewable resources (e.g. hydropower, wind energy, solar, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account.

LCA Metadata

NOTES

The following list provides a summary of all materials and energy inputs present in the selected study. Materials are listed in alphabetical order along with a list of all Revit families and Tally entries in which they occur and any notes and system boundaries accompanying their database entries. The mass given here refers to the full life-cycle mass of material, including manufacturing and replacement.

Aluminum, extruded	5,621.2 kg

Used in the following Revit families:

1100mm	0.0 kg
Quad Corner Mullion: Quad Mullion 1	288.1 kg
Rectangular Mullion: 50 x 120mm	363.0 kg
Rectangular Mullion: 50 x 150mm	4,970.1 kg

Used in the following Tally entries:
Aluminum, extrusion

Description:
Extruded aluminum part

Life Cycle Inventory:
Aluminum, process energy

Manufacturing Scope:
Cradle to gate

End of Life Scope:
95% recovered (includes recycling, scrap preparation, and avoided burden credit)
5% landfilled (inert material)

Entry Source:
NA: Primary Aluminium Ingot AA (2011)
EU-27: Aluminium extrusion profile PE (2012)

Cross laminated timber (CrossLam)	552,386.1 kg

Used in the following Revit families:

CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel	967.5 kg
CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel	1,589.3 kg
CLT Corner Panel: CLT Corner Panel Full Height NE-SE	1,752.0 kg
CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door	1,493.4 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	19,467.7 kg
CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1	8,086.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm	459.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1006mmx2440mm	154.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1014mmx2440mm	1,396.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1022mmx2440mm	156.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1058mmx2440mm	303.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1078mmx2440mm	165.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1092mmx2440mm	334.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1100mmx2440mm	673.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1107mmx2440mm	169.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1115mmx2440mm	341.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1123mmx2440mm	1,031.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1127mmx2440mm	485.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1130mmx2440mm	810.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1145mmx2440mm	525.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1160mmx2440mm	355.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1192mmx2440mm	729.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1204mmx2440mm	184.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1212mmx2440mm	1,483.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1219mmx2440mm	746.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1220mmx2440mm	80,656.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1228mmx2440mm	187.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1232mmx2440mm	377.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1260mmx2440mm	192.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1274mmx2440mm	389.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1284mmx2440mm	368.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1286mmx2440mm	184.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1305mmx2440mm	187.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1334mmx2440mm	191.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1340mmx2440mm	820.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1352mmx2440mm	581.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1375mmx2440mm	210.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1383mmx2440mm	634.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1411mmx2440mm	2,375.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1434mmx2440mm	5,266.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1435mmx2440mm	219.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1442mmx2440mm	2,206.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1448mmx2440mm	443.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1455mmx2440mm	222.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 151mmx2440mm	86.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1531mmx2440mm	3,045.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1539mmx2440mm	2,355.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1542.8mmx2440mm	236.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm	1,423.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1578mmx2440mm	241.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1652mmx2440mm	474.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1702mmx2440mm	781.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1738mmx2440mm	266.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1740mmx2440mm	798.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1756mmx2440mm	537.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1764mmx2440mm	539.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1800mmx2440mm	275.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1850mmx2440mm	2,123.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1852mmx2440mm	283.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1860mmx2440mm	569.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1876mmx2440mm	287.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1878mmx2440mm	862.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm	1,152.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm 2	576.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1910mmx2440mm	1,753.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm	29.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1932mmx2440mm	591.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1941mmx2440mm	297.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1942mmx2440mm	3,863.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1944mmx2440mm	297.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1946mmx2440mm	595.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1950mmx2440mm	298.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1954mmx2440mm	2,392.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1973mmx2440mm	603.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1988mmx2440mm	912.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1991mmx2440mm	609.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2002.2mmx2440mm	306.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm	928.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2033mmx2440mm	622.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2038mmx2440mm	1,871.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2048mmx2440mm	313.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2049mmx2440mm	313.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2050mmx2440mm	313.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2056mmx2440mm	629.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2064mmx2440mm	315.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2111mmx2440mm	1,211.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2196mmx2440mm	336.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2372mmx2440mm	5,082.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2380mmx2440mm	728.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2440mmx2440mm	1,400.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2484mmx2440mm	2,280.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2492mmx2440mm	1,525.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2760mmx2440mm	396.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 290mmx2440mm	44.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 350mmx2440mm	200.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 462mmx2440mm	70.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 488mmx2440mm	74.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 535mmx2440mm	163.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 538mmx2440mm	164.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 543mmx2440mm	249.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 551mmx2440mm	84.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 556mmx2440mm	170.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 559mmx2440mm	85.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 616.2mmx2440mm	943.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 620mmx2440mm	94.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 640mmx2440mm	489.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 648mmx2440mm	99.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 670mmx2440mm	410.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 682mmx2440mm	195.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 696mmx2440mm	106.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 700mmx2440mm	428.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 710mmx2440mm	326.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 750mmx2440mm	5,165.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 772mmx2440mm	354.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 814mmx2440mm	124.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 822mmx2440mm	503.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 830mmx2440mm	3,302.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 842mmx2440mm	773.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 876.9mmx2440mm	268.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 877mmx2440mm	134.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 896mmx2440mm	137.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 930mmx2440mm	284.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 950mmx2440mm	1,744.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 958mmx2440mm	439.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 978mmx2440mm	140.3 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1220mmx732mm	4,256.9 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1320mmx732mm	56.8 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1490mmx732mm	547.3 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1530mmx732mm	65.9 kg

LCA Metadata (continued)

CLT Full Panel 1220mmx2440mm: CLT Half Panel 1610mmx732mm	517.4 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1990mmx732mm	85.7 kg
CLT Timber	201,344.7 kg
CLT Window Ope Center 910mm: CLT Window Ope Center 910mm	11,589.9 kg
CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm	1,617.2 kg
CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus ...	1,208.3 kg
Cross Laminated Timber CLT	4,582.3 kg
Cross Laminated Timber Mass 100mm	239.0 kg
Cross Laminated Timber Mass 188mm	2,241.5 kg
Cross Laminated Timber Mass 300	118,945.6 kg

Used in the following Tally entries:
Cross laminated timber (CrossLam / CLT)

Description:
PROXIED by LVL

Life Cycle Inventory:
43% PNW
57% SE
Proxied by LVL

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
US: Laminated veneer lumber, at plant, US PNW USLCI/PE (2009)
US: Laminated veneer lumber, at plant, US SE USLCI/PE (2009)

Domestic softwood, US — 4,263.9 kg

Used in the following Revit families:

24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L...	1,985.0 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	1,973.6 kg
IntSgl (7): 1010 x 2110mm	74.4 kg
IntSgl (7): 810 x 2110mm	128.8 kg
IntSgl (7): 910 x 2110mm	102.2 kg

Used in the following Tally entries:
Domestic softwood

Description:
Dimensional lumber, sawn, planed, dried and cut for standard framing or planking

Life Cycle Inventory:
38% PNW
62% SE
Dimensional lumber

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Surfaced dried lumber, at planer mill, PNW USLCI/PE (2009)
US: Surfaced dried lumber, at planer mill, SE USLCI/PE (2009)

Door frame, wood, no door — 279.1 kg

Used in the following Revit families:

IntSgl (7): 1010 x 2110mm	68.0 kg
IntSgl (7): 810 x 2110mm	117.7 kg
IntSgl (7): 910 x 2110mm	93.4 kg

Used in the following Tally entries:
Door frame, wood

Description:
Wood door frame

Life Cycle Inventory:
Dimensional lumber

Manufacturing Scope:
Cradle to gate, excludes hardware, jamnb, casing, sealant

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
DE: Wooden frame (EN15804 A1-A3) PE (2012)

Door, interior, wood, MDF Core, flush — 17,360.9 kg

Used in the following Revit families:

24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L...	7,733.9 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	7,689.4 kg
IntSgl (7): 1010 x 2110mm	523.0 kg
IntSgl (7): 810 x 2110mm	754.9 kg
IntSgl (7): 910 x 2110mm	659.7 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Interior flush wood door with MDF core

Life Cycle Inventory:
12.2 kg/m² Wood, 0.052 m3/m3 MDF

Manufacturing Scope:
Cradle to gate, excludes assembly, frame, hardware, and adhesives

End of Life Scope:
14.5% wood products recovered (credited as avoided burden)
22% wood products incinerated with energy recovery
63.5% wood products landfilled (wood product waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)
DE: Wood fibre board PE (2012)

Flooring, bamboo plank — 354,685.0 kg

Used in the following Revit families:

24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	1.3 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	15.1 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	2.0 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	15.9 kg
24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Pan...	2,114.2 kg
24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Pan...	15.0 kg
24mm LVB Corner Panel Adaptable 2440mm x Length x Length: 24mm LVB ...	693.9 kg
24mm LVB Corner Panel Half Adaptable 2440mm x Length x Length: 24mm...	1,064.8 kg
24mm LVB Door Ope Panel 2440x1220x128 NO Door A: 24mm LVB Door Ope ...	662.5 kg
24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L...	5,489.5 kg
24mm LVB Level 8 Window 300 x 910mm Offset: 24mm LVB Level 8 Window...	71.3 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 120	29.8 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 122	10.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 132	21.2 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 147	11.4 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 151	46.5 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 160	12.1 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 163.2	36.8 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 191	82.8 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 214	316.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 221	61.7 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 222	15.5 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 223.1	46.6 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 228	47.4 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 230	63.7 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 231	63.9 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 241	49.6 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 248	16.9 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 251	68.3 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 255	51.9 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 259	17.5 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 260	70.2 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 264	53.3 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 270	18.1 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 272	72.8 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 282	18.8 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 310	304.2 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 320	666.5 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 322	20.9 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 330.2	171.1 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 331	300.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 334	215.9 kg

LCA Metadata (continued)

24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 342	308.4 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 355	90.9 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 358	91.6 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 432	53.9 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 72	21.9 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1000m...	179.8 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1014m...	485.2 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1022m...	183.2 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1036m...	61.8 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1058m...	62.9 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1078m...	63.9 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1100m...	1,951.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1130m...	266.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1145m...	269.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1152m...	1,083.2 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1160m...	272.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1192m...	279.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1212m...	353.8 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1216m...	71.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1220m...	6,403.2 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x520mm...	35.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x538mm...	72.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x554mm...	74.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616.2...	403.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616mm...	40.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x620mm...	40.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x630mm...	328.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x662mm...	85.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x666mm...	128.6 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x670mm...	172.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x682mm...	87.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x690mm...	132.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x698mm...	178.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x702mm...	44.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x710mm...	180.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x712mm...	90.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x722mm...	640.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x730mm...	46.1 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x732mm...	46.2 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x734mm...	463.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x750mm...	2,169.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x760mm...	95.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x770mm...	96.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x772mm...	289.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x776mm...	145.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x803mm...	149.6 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x818mm...	303.8 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x821mm...	457.1 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x826mm...	153.1 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x829mm...	102.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x830mm...	2,101.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x832mm...	205.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x836mm...	154.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x842mm...	622.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x876.9...	53.2 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x877mm...	53.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x891mm...	163.1 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x900mm...	109.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x922mm...	56.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x930mm...	112.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x950mm...	918.1 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x976mm...	58.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x978mm...	58.8 kg
24mm Window 910mm Center 1220x2440mm: 24mm Window 910mm Center 1220...	5,027.3 kg
Bamboo LVB	3,740.6 kg
Generic Bamboo Mass 100	195.1 kg
Generic Bamboo Mass 188mm	1,829.8 kg
Generic Bamboo Mass 300	97,176.2 kg
LVB Bamboo Floor	164,371.7 kg
Quad Corner Mullion: Quad Mullion Bamboo	43.2 kg
Rectangular Mullion: 50 x 120mm Bamboo	53.7 kg
Rectangular Mullion: 50 x 150mm Bamboo	741.9 kg
Window 910mm Offset 1220 x 2440mm: 24mm LVB Window 910mm Offset 1220...	3,214.4 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Bamboo plank flooring

Life Cycle Inventory:
90% Bamboo, 10% phenol formaldehyde

Manufacturing Scope:
Cradle to gate for raw material only, includes transportation from China and estimate for material processing neglects materials for installation

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
CN: Bamboo (estimation) PE (2012)
GLO: Bulk commodity carrier PE (2012)
US: Heavy fuel oil at refinery (0.3wt.% S) PE (2010)
CN: Electricity grid mix PE (2010)
DE: Phenol formaldehyde resin PE (2012)

Glazing, triple, insulated (argon), low-E — 9,621.3 kg

Used in the following Revit families:

System Panel: Glazed	9,621.3 kg

Used in the following Tally entries:
Glazing, triple pane IGU

Description:
Glazing, triple, insulated (argon filled), 1/8" float glass, low-E, inclusive of argon gas fill, sealant, and spacers

Life Cycle Inventory:
32.4 kg/m² glass
Argon filled, 0.15 kg/m² low-e coating

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Insulation glass compound (3 panes) PE (2012)

Hardware, stainless steel — 9.1 kg

Used in the following Revit families:

24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L...	0.6 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	0.6 kg
IntSgl (7): 1010 x 2110mm	2.1 kg
IntSgl (7): 810 x 2110mm	3.1 kg
IntSgl (7): 910 x 2110mm	2.7 kg

Used in the following Tally entries:
Stainless steel, hardware

Description:
Finished, cast stainless steel entry applicable for door, window or other accessory hardware

Life Cycle Inventory:
Stainless steel

Manufacturing Scope:
Cradle to gate

End of Life Scope:
98% recovered (product has 58.1% scrap input while remainder is processed and credited as avoided burden)
2% landfilled (inert material)

Entry Source:
RER: Stainless steel Quarto plate (304) Eurofer (2008)
DE: Steel cast part machining PE (2012)
US: Electricity grid mix PE (2010)
RER: Stainless steel flat product (304) - value of scrap Eurofer (2008)

Interior grade plywood, US — 1,023.1 kg

Used in the following Revit families:

Stair	1,023.1 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Plywood, unfinished

LCA Metadata (continued)

Life Cycle Inventory:
33% PNW
67% SE
Plywood
Proxied by exterior grade plywood

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)

None	0.0 kg

Used in the following Revit families:

24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	0.0 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	0.0 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	0.0 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	0.0 kg
24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Pan...	0.0 kg
24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Pan...	0.0 kg
24mm LVB Corner Panel Adaptable 2440mm x Length x Length: 24mm LVB ...	0.0 kg
24mm LVB Corner Panel Half Adaptable 2440mm x Length x Length: 24mm...	0.0 kg
24mm LVB Door Ope Panel 2440x1220x128 NO Door A: 24mm LVB Door Ope ...	0.0 kg
24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L...	0.0 kg
24mm LVB Level 8 Window 300 x 910mm Offset: 24mm LVB Level 8 Window...	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 120	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 122	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 132	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 147	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 151	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 160	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 163.2	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 191	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 214	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 221	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 222	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 223.1	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 228	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 230	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 231	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 241	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 248	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 251	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 255	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 259	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 260	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 264	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 270	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 272	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 282	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 310	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 320	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 322	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 330.2	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 331	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 334	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 342	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 355	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 358	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 432	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 72	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1000m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1014m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1022m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1036m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1058m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1078m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1100m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1130m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1145m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1152m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1160m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1192m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1212m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1216m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1220m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x520mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x538mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x554mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616.2...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x620mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x630mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x662mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x666mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x670mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x682mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x690mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x698mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x702mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x710mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x712mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x722mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x730mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x732mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x734mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x750mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x760mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x770mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x772mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x776mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x803mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x818mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x821mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x826mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x829mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x830mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x832mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x836mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x842mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x876.9...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x877mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x891mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x900mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x922mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x930mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x950mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x976mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x978mm...	0.0 kg
24mm Window 910mm Center 1220x2440mm: 24mm Window 910mm Center 1220	0.0 kg
Bamboo LVB	0.0 kg
CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel	0.0 kg
CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel	0.0 kg
CLT Corner Panel: CLT Corner Panel Full Height NE-SE	0.0 kg
CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door	0.0 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	0.0 kg
CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1...	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1006mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1014mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1022mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1058mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1078mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1092mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1100mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1107mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1115mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1123mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1127mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1130mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1145mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1160mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1192mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1204mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1212mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1219mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1220mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1228mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1232mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1260mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1274mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1284mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1286mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1305mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1334mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1340mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1352mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1375mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1383mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1411mmx2440mm	0.0 kg

LCA Metadata (continued)

CLT Full Panel 1220mmx2440mm: CLT Full Panel 1434mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1435mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1442mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1448mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1455mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 151mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1531mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1539mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1542.8mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1578mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1652mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1702mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1738mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1740mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1756mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1764mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1800mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1850mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1852mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1860mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1876mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1878mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm 2	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1910mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1932mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1941mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1942mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1944mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1946mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1950mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1954mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1973mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1988mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1991mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2002.2mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2033mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2038mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2048mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2049mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2050mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2056mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2064mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2111mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2196mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2372mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2380mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2440mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2484mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2492mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2760mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 290mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 350mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 462mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 488mmx2440mm	0.0 kg
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CLT Full Panel 1220mmx2440mm: CLT Full Panel 543mmx2440mm	0.0 kg
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CLT Full Panel 1220mmx2440mm: CLT Full Panel 559mmx2440mm	0.0 kg
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CLT Full Panel 1220mmx2440mm: CLT Full Panel 640mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 648mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 670mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 682mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 696mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 700mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 710mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 750mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 772mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 814mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 822mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 830mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 842mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 876.9mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 877mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 896mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 930mmx2440mm	0.0 kg
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CLT Full Panel 1220mmx2440mm: CLT Half Panel 1220mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1320mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1490mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1530mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1610mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1990mmx732mm	0.0 kg
CLT Timber	0.0 kg
CLT Window Ope Center 910mm: CLT Window Ope Center 910mm	0.0 kg
CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm	0.0 kg
CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus ...	0.0 kg
Cross Laminated Timber CLT	0.0 kg
Cross Laminated Timber Mass 100mm	0.0 kg
Cross Laminated Timber Mass 188mm	0.0 kg
Cross Laminated Timber Mass 300	0.0 kg
Generic Bamboo Mass 100	0.0 kg
Generic Bamboo Mass 188mm	0.0 kg
Generic Bamboo Mass 300	0.0 kg
IntSgl (7): 1010 x 2110mm	0.0 kg
IntSgl (7): 810 x 2110mm	0.0 kg
IntSgl (7): 910 x 2110mm	0.0 kg
LVB Bamboo Floor	0.0 kg
Stair	0.0 kg
Window 910mm Offset 1220 x 2440mm: 24mm LVB Window 910mm Offset 122...	0.0 kg

Used in the following Tally entries:
- Cross laminated timber (CrossLam / CLT)
- Domestic softwood
- Door, interior, wood, MDF core, flush
- Flooring, bamboo plank
- Flooring, engineered wood plank

Description:
This entry is a placeholder, for use in cases when there is "no" finish, or "no added material designated.

Manufacturing Scope:
NA

Entry Source:
None

Polyurethane floor finish, water-based 203.7 kg

Used in the following Revit families:

Quad Corner Mullion: Quad Mullion Bamboo	0.0 kg
Rectangular Mullion: 50 x 120mm Bamboo	0.0 kg
Rectangular Mullion: 50 x 150mm Bamboo	0.3 kg
Stair	203.3 kg

Used in the following Tally entries:
- Flooring, bamboo plank
- Flooring, engineered wood plank

Description:
Water-based polyurethane wood stain, inclusive of catalyst

Life Cycle Inventory:
97.7% stain (50% water, 35% polyurethane dispersions, 5% dipropylene glycol dimethyl ether, 5% tri-butoxyethyl phosphate, 5% dipropylene glycol methyl ether), 2.3% catalyst (75% polyfunctional aziridine, 25% 2-propoxyethanol)
24.5% NMVOC emissions during application

Manufacturing Scope:
Cradle to gate, including emissions during application

End of Life Scope:
26.7% solids to landfill (plastic waste)

Entry Source:
DE: Ethylene glycol butyl ether PE (2012)
US: Epichlorohydrin (by product calcium chloride, hydrochloric acid) PE (2012)
DE: Propylenglycolmonomethylether (Methoxypropanol) PGME PE (2012)
US: Tap water from groundwater PE (2012)
DE: Polyurethane (copolymer-component) (estimation from TPU adhesive) PE (2012)
US: Electricity grid mix PE (2010)

LCA Metadata (continued)

Powder coating, metal stock — 90.2 kg

Used in the following Revit families:
- 1100mm — 72.5 kg
- Quad Corner Mullion: Quad Mullion 1 — 0.5 kg
- Rectangular Mullion: 50 x 120mm — 1.2 kg
- Rectangular Mullion: 50 x 150mm — 16.0 kg

Used in the following Tally entries:
Aluminum, extrusion

Description:
Powder coating, for metal stock

Manufacturing Scope:
Cradle to gate, including application

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Application top coat powder (aluminium) PE (2012)
DE: Coating powder (industry
outside
red) PE (2012)

Stainless steel, door hardware, lever lock, interior, residential — 2,307.0 kg

Used in the following Revit families:
- 24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L... — 712.2 kg
- CLT Door Ope 900mm: CLT Door Ope 900mm — 1,416.3 kg
- IntSgl (7): 1010 x 2110mm — 48.2 kg
- IntSgl (7): 810 x 2110mm — 69.5 kg
- IntSgl (7): 910 x 2110mm — 60.8 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Stainless steel door fitting (hinges and lockset) for use on residential interior door assemblies.

Life Cycle Inventory:
Door hinges 0.622 kg/part, Battalion Lever Lockset, Light Duty, Privacy 0.70 kg/part

Manufacturing Scope:
Cradle to gate, including disposal of packaging.

End of Life Scope:
90% collection rate
remaining 10% deposited in the LCA model without recycling
material recycling efficiency dependant on the metal (89% steel, 90.2% aluminum, stainless steel 83%, zinc 91%, brass 94%)
Plastic components incinerated resulting in credits for electricity and thermal energy

Entry Source:
DE: Fitting stainless steel - FSB (2009)

Urethane adhesive — 190.1 kg

Used in the following Revit families:
- Quad Corner Mullion: Quad Mullion Bamboo — 5.1 kg
- Rectangular Mullion: 50 x 120mm Bamboo — 13.3 kg
- Rectangular Mullion: 50 x 150mm Bamboo — 171.8 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Urethane adhesive for use with flooring and wall coverings.

Life Cycle Inventory:
50% limestone, 13% lime, 30% polyurethane, 1.5% stearic acid, 5% Methylene bis(phenylisocyanate) (MDI)
1.3% NMVOC emissions

Manufacturing Scope:
Cradle to gate, plus emissions during application

End of Life Scope:
98.7% solids to landfill (plastic waste)

Entry Source:
US: Limestone flour (5mm) PE (2012)
DE: Polyurethane (copolymer-component) (estimation from TPU adhesive) PE (2012)
US: Lime (CaO) calcination PE (2012)
US: Methylene diisocyanate (MDI) PE (2012)
DE: Stearic acid PE (2012)
US: Electricity grid mix PE (2010)

Veneer, hardwood — 307.1 kg

Used in the following Revit families:
- Stair — 307.1 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Hardwood veneer

Life Cycle Inventory:
43% PNW
57% SE
veneer

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% landfilled (biodegradable waste)

Entry Source:
US: Dry veneer, at plywood plant, PNW USLCI/PE (2009)
US: Dry veneer, at plywood plant, SE USLCI/PE (2009)

Stadthaus, Murray Grove

24mm x 128mm Ply Panels v 128mm Mass Bamboo

02/03/2016

Table of Contents

Report Summary

Created with Tally
Non-commercial Version 2014.06.17.01

Author : Philip Kavanagh
Company : Dublin Institute of Technology
Date : 02/03/2016

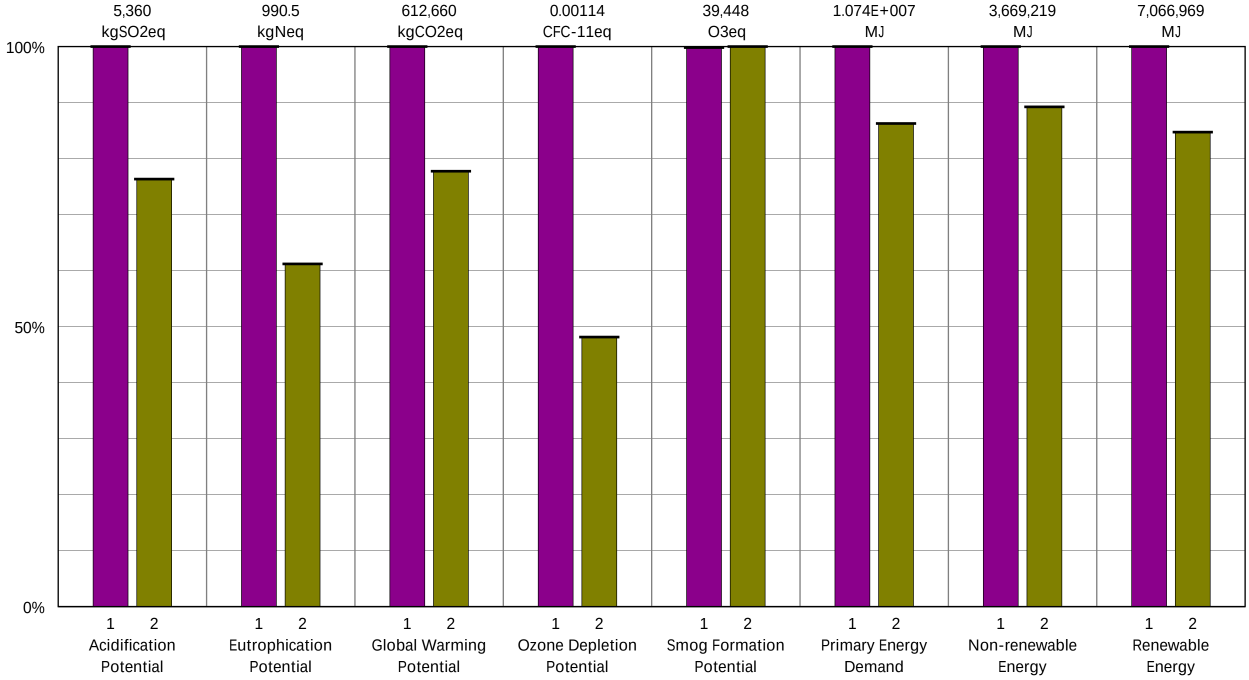
Project : Stadthaus, Murray Grove
Location : London, England
Gross Area : 2782.998 m²
Building Life : 50

Scope : Cradle-to-Grave, exclusive of operational energy

Goal of Assessment :
To determine the global warming potential, through life cycle analysis, of laminated veneer bamboo diaphragm panel construction over the selection of cross laminated timber panels for mid to high rise residential accommodation.

Object of Study

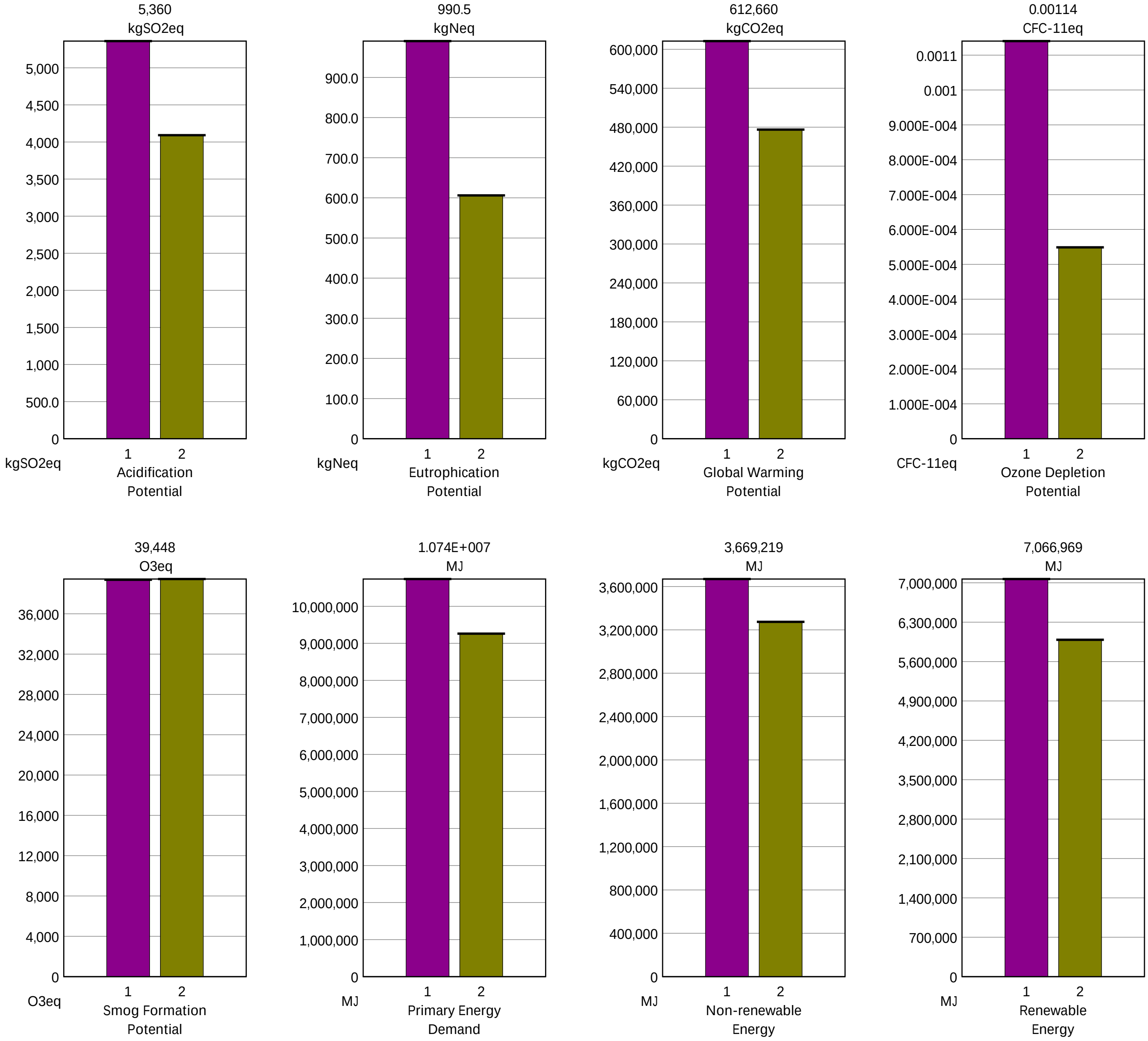
Design options set 'Option Set 1'
Mass Bamboo Panel
Plywood Hybrid Box (primary)



Legend

Design Options
Mass Bamboo Panel
Plywood Hybrid Box (primary)

Report Summary (continued)

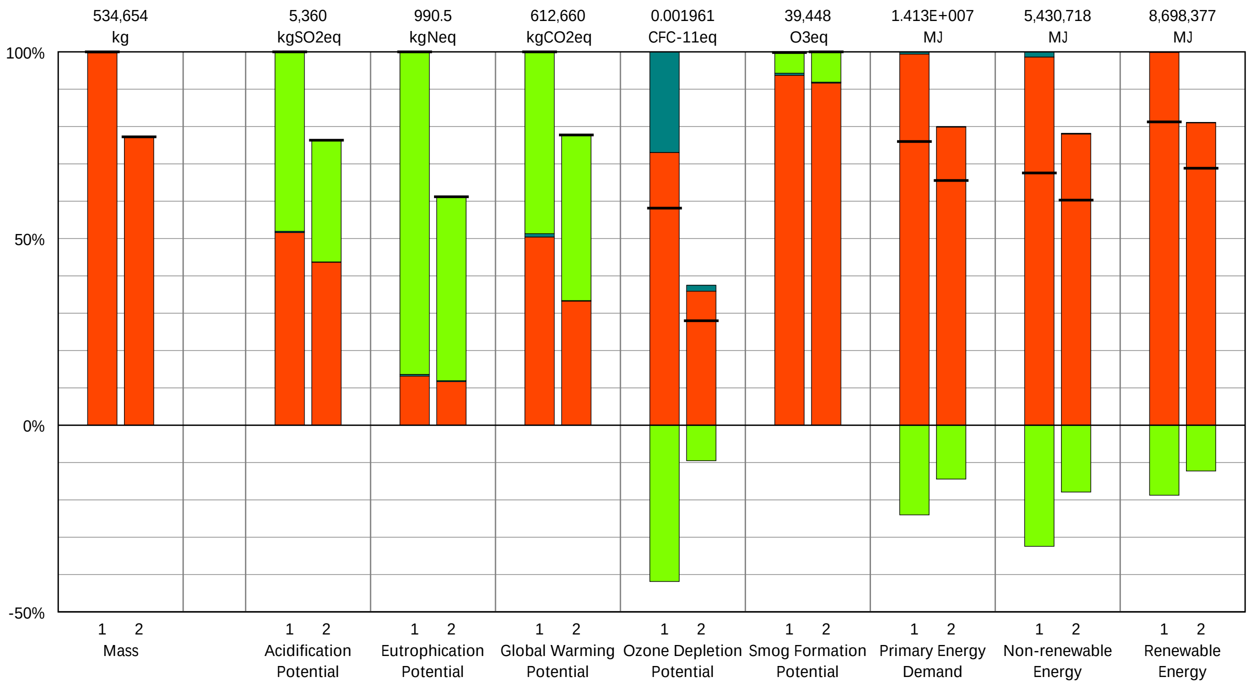


Legend

Design Options

- Mass Bamboo Panel
- Plywood Hybrid Box (primary)

Results per Life Cycle Stage



Legend

Net value (impacts + credits)

Design Options

Option 1 - Mass Bamboo Panel

Option 2 - Plywood Hybrid Box (primary)

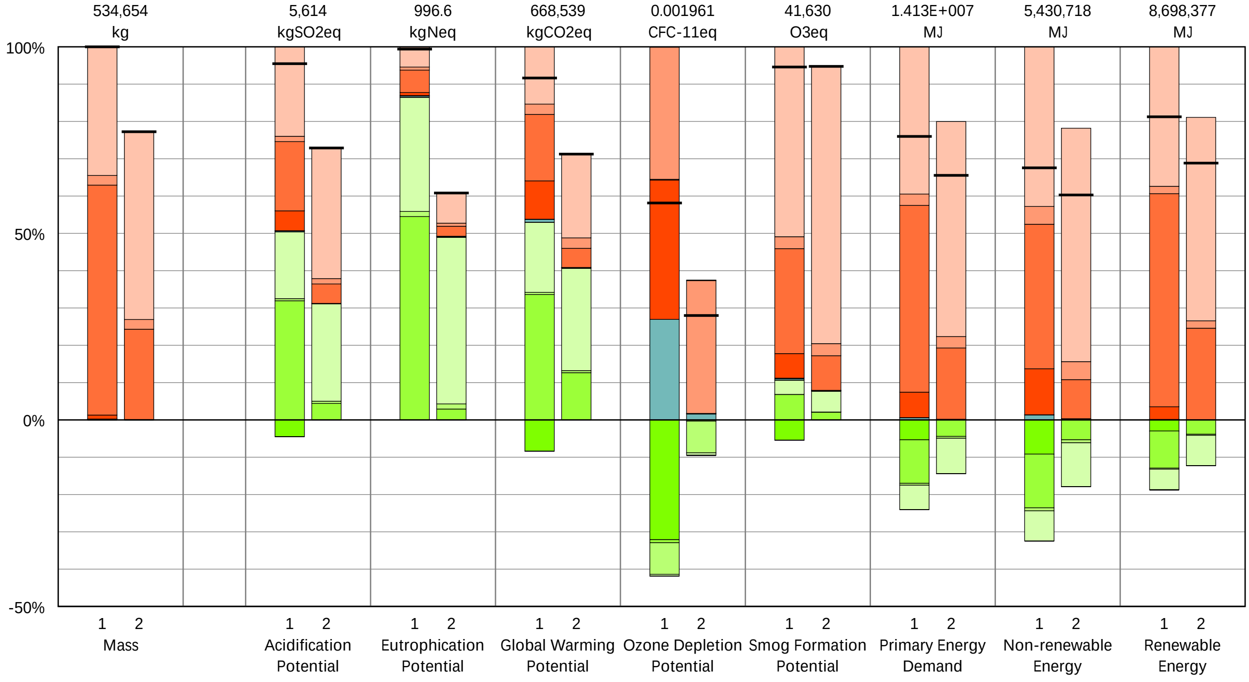
Life Cycle Stages

Manufacturing

Maintenance and Replacement

End of Life

Results per Life Cycle Stage, itemized by CSI Division



Legend

Net value (impacts + credits)

Design Options

Option 1 - Mass Bamboo Panel

Option 2 - Plywood Hybrid Box (primary)

Manufacturing

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

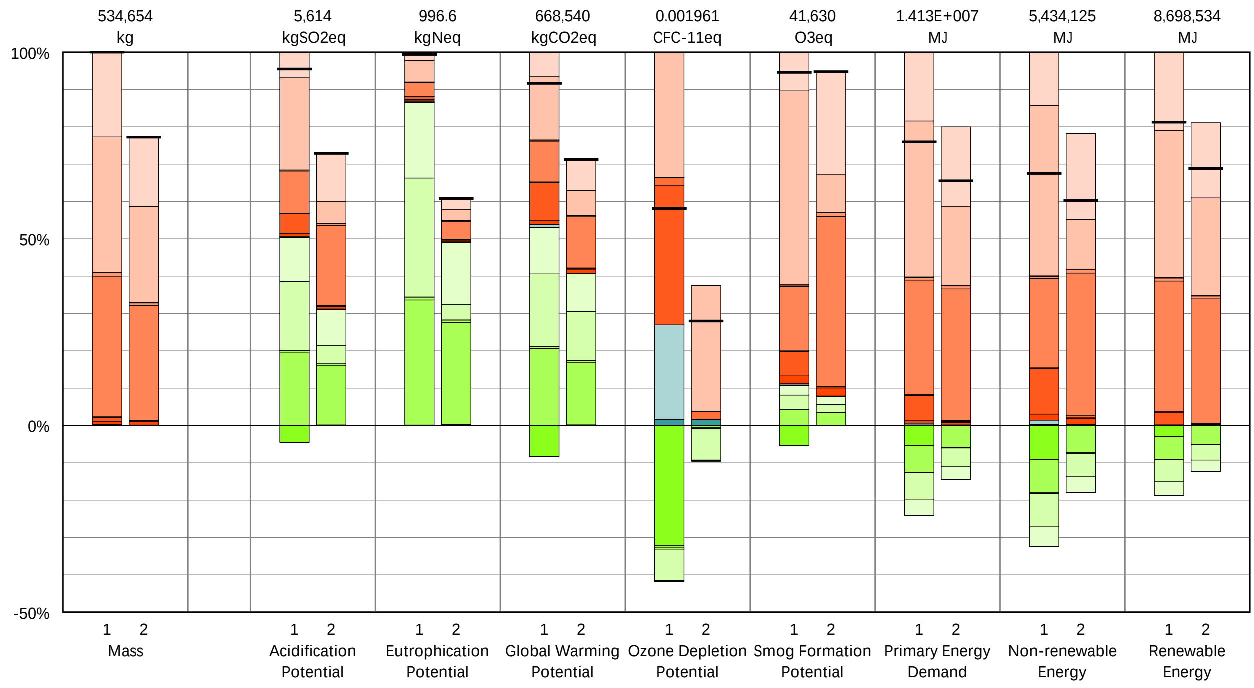
Maintenance and Replacement

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

End of Life

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

Results per Life Cycle Stage, itemized by Revit Category



Legend

Net value (impacts + credits)

Design Options

Option 1 - Mass Bamboo Panel

Option 2 - Plywood Hybrid Box (primary)

Manufacturing

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

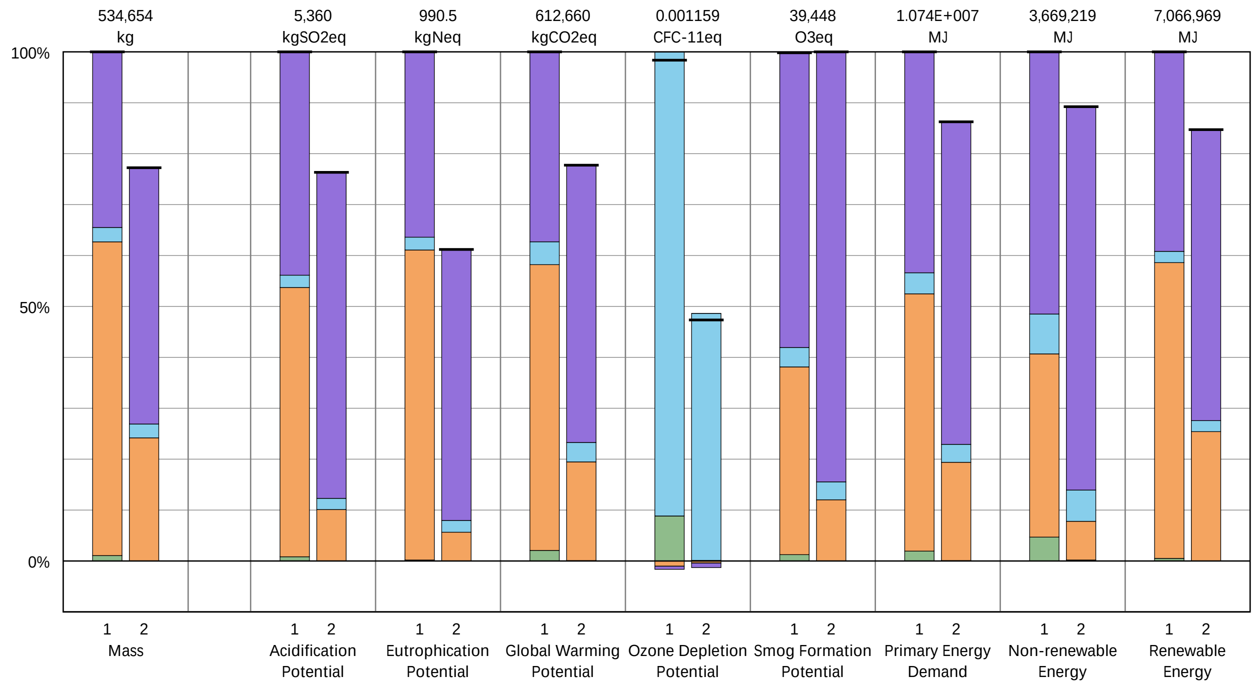
Maintenance and Replacement

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

End of Life

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per CSI Division



Legend

Design Options

Option 1 - Mass Bamboo Panel

Option 2 - Plywood Hybrid Box (primary)

CSI Divisions

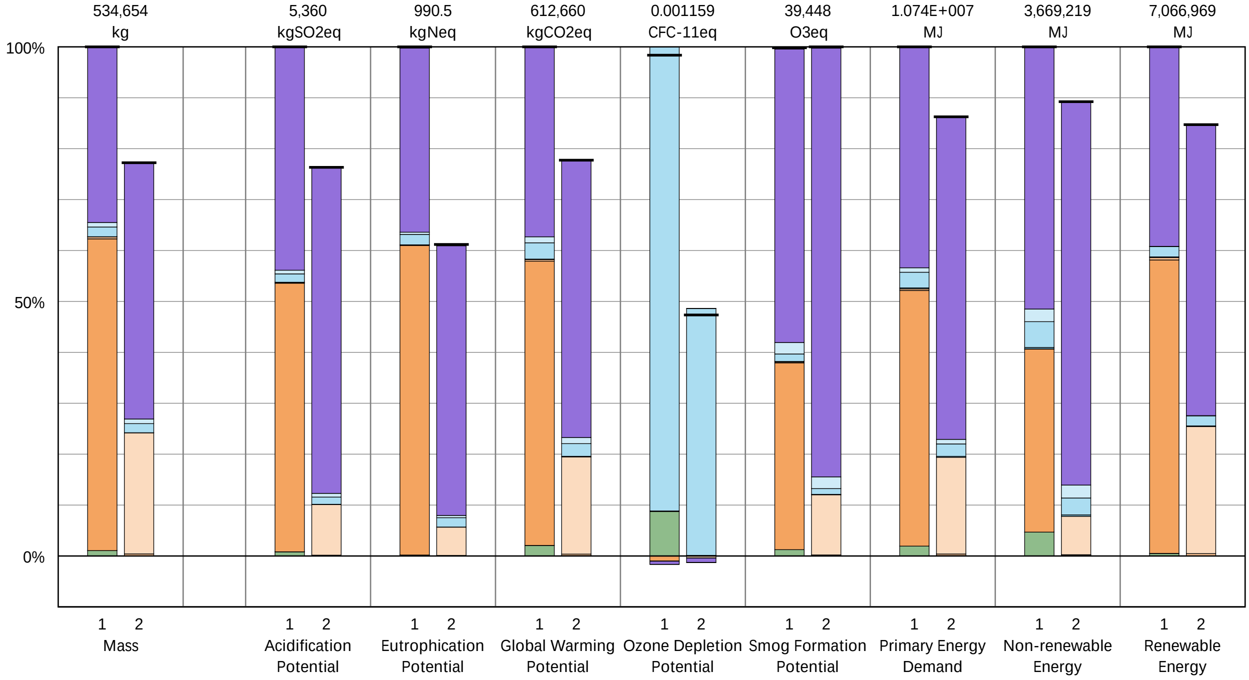
05 - Metals

06 - Wood/Plastics/Composites

08 - Openings and Glazing

09 - Finishes

Results per CSI Division, itemized by Tally Entry



Legend

Design Options

Option 1 - Mass Bamboo Panel

Option 2 - Plywood Hybrid Box (primary)

05 - Metals

- Aluminum, extrusion
- Stainless steel, hardware

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam / CLT)
- Domestic softwood
- Plywood, exterior grade

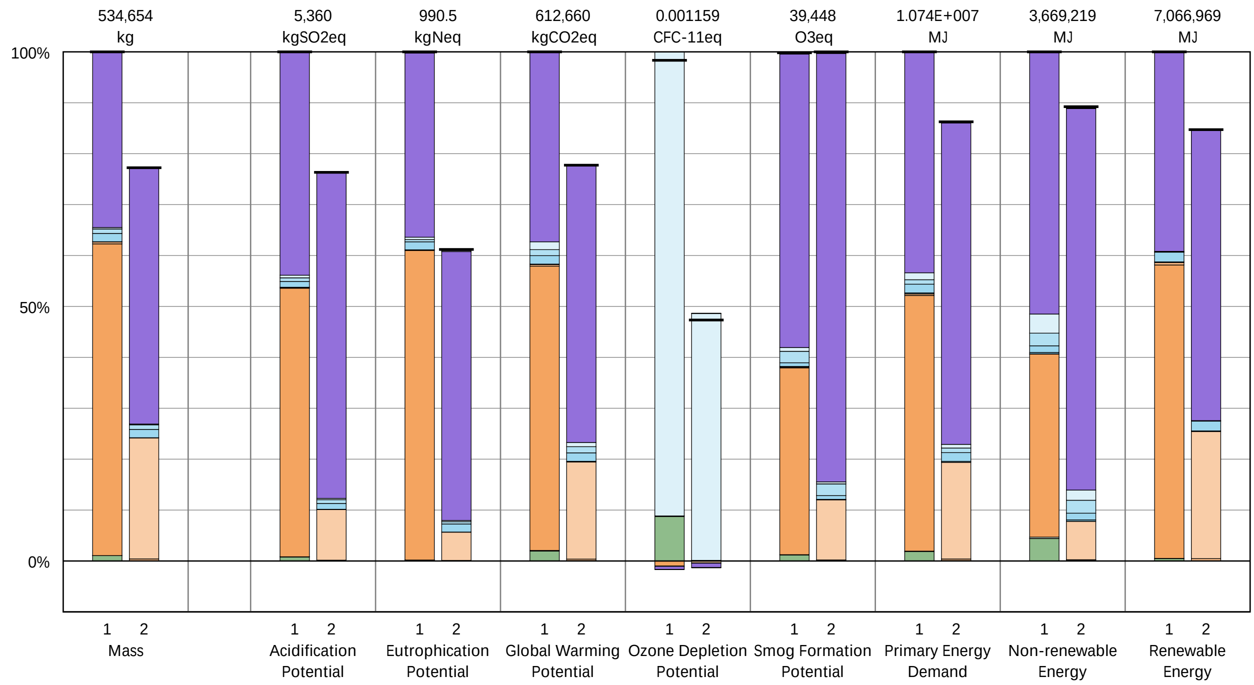
08 - Openings and Glazing

- Door frame, wood
- Door, interior, wood, MDF core, flush
- Glazing, triple pane IGU

09 - Finishes

- Flooring, bamboo plank
- Flooring, engineered wood plank

Results per CSI Division, itemized by Material



Legend

Design Options

Option 1 - Mass Bamboo Panel

Option 2 - Plywood Hybrid Box (primary)

05 - Metals

- Aluminum, extruded
- Hardware, stainless steel
- Powder coating, metal stock

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam)
- Domestic softwood, US
- Exterior grade plywood, US
- None

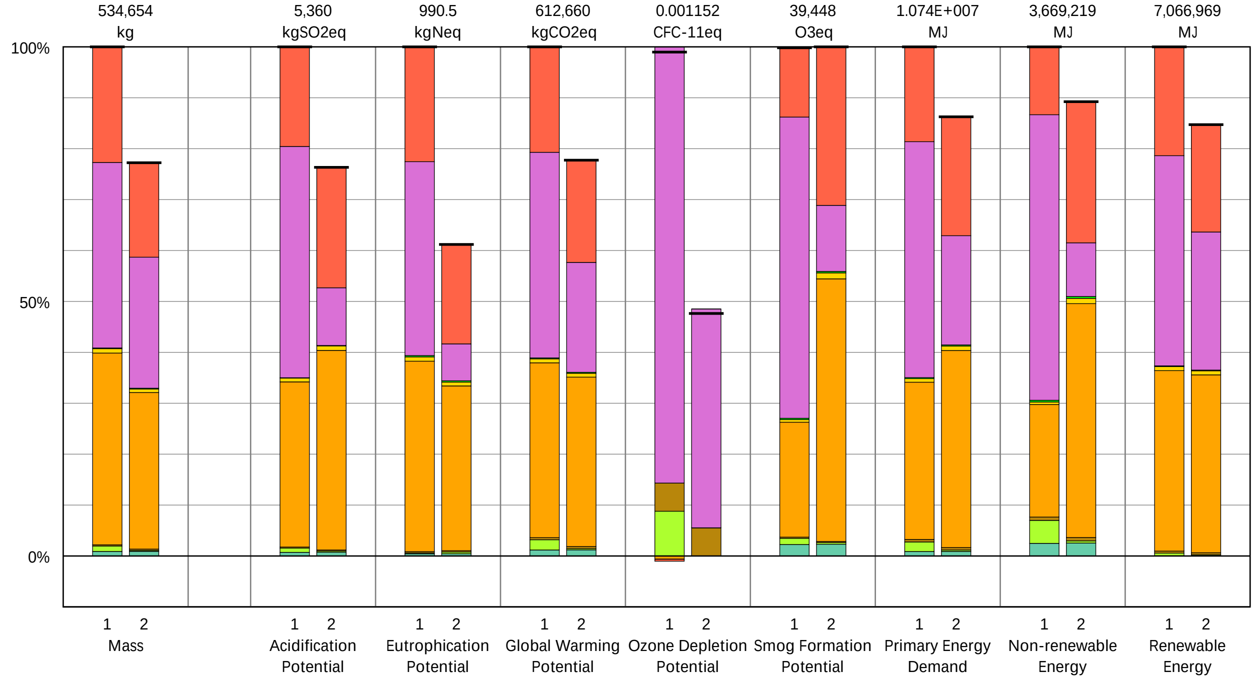
08 - Openings and Glazing

- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Glazing, triple, insulated (argon), low-E
- None
- Stainless steel, door hardware, lever lock, interior, residential

09 - Finishes

- Flooring, bamboo plank
- Interior grade plywood, US
- None
- Polyurethane floor finish, water-based
- Urethane adhesive
- Veneer, hardwood

Results per Revit Category



Legend

Design Options

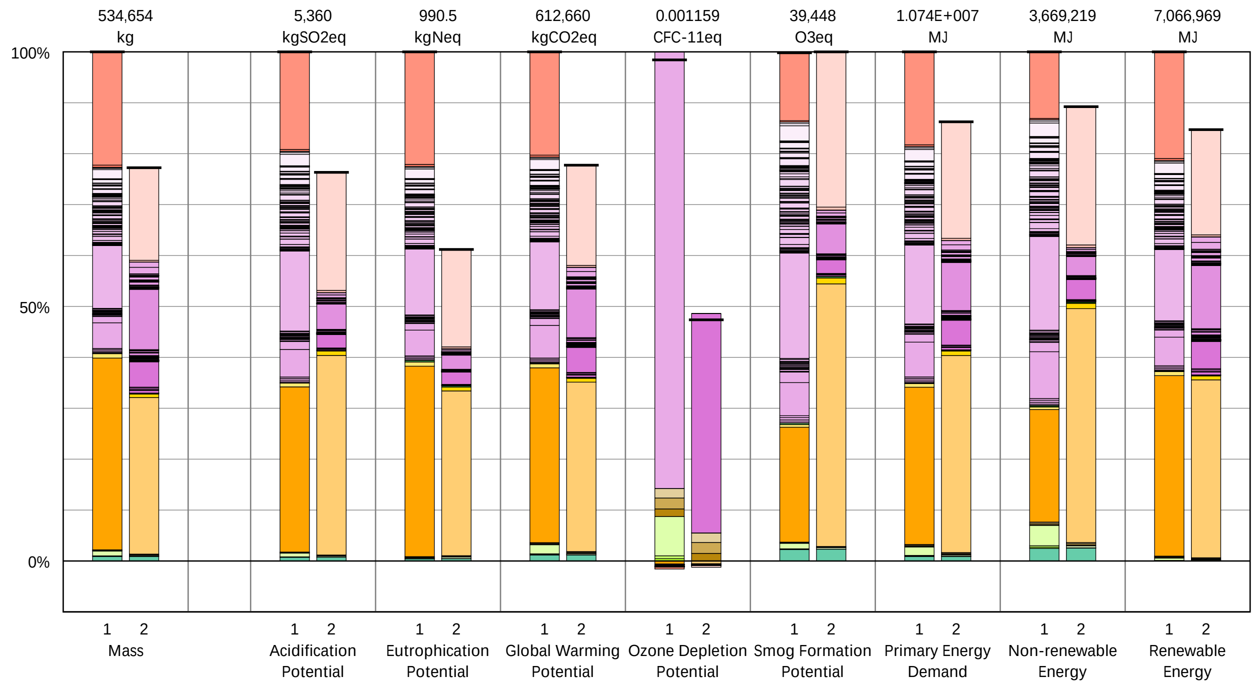
Option 1 - Mass Bamboo Panel

Option 2 - Plywood Hybrid Box (primary)

Revit Categories

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per Revit Category, itemized by Family



Legend

Design Options

Option 1 - Mass Bamboo Panel
Option 2 - Plywood Hybrid Box (primary)

Curtain Panels

System Panel: Glazed

Curtain Wall Mullions

Quad Corner Mullion: Quad Mullion 1
Quad Corner Mullion: Quad Mullion Bamboo
Rectangular Mullion: 50 x 120mm
Rectangular Mullion: 50 x 120mm Bamboo
Rectangular Mullion: 50 x 150mm
Rectangular Mullion: 50 x 150mm Bamboo

Doors

IntSgl (7): 1010 x 2110mm
IntSgl (7): 810 x 2110mm
IntSgl (7): 910 x 2110mm

Floors

CLT Timber
LVB Bamboo Floor

Roofs

Bamboo LVB
Cross Laminated Timber CLT

Stairs and Railings

1100mm
Stair

Structure

24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel Single 100mm
24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel Single 270mm
24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel Single 310mm
24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel Single 390mm
24mm Ply Balcony Half Panel 732 x 1220 A: 24mm Ply Balcony Half Panel 732 x 1...
24mm Ply Balcony Half Panel 732 x 1220 A: 24mm Ply Balcony Half Panel 732 x 762
24mm Ply Corner Panel Adaptable 2440mm x Length x Length: 24mm Ply Corner Pan...
24mm Ply Corner Panel Half Adaptable 2440mm x Length x Length: 24mm Ply Corne...
24mm Ply Door Ope Panel 2440x1220x128 NO Door A: 24mm Ply Door Ope Panel 2440...
24mm Ply Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm Ply Door Op...
24mm Ply Level 8 Window 300 x 910mm Offset: 24mm Ply Level 8 Window 300 x 910...
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 120
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 122
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 132
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 147
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 151
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 160
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 163.2
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 191
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 214
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 221
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 222
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 223.1
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 228
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 230
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 231
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 241
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 248
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 251
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 255
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 259
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 260
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 264
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 270
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 272
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 282
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 310
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 320
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 322
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 330.2
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 331
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 334
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 342
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 355
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 358
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 432
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 72
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1000mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1014mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1022mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1036mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1058mm Panel

Results per Revit Category, itemized by Family (continued)

Legend (continued)

24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1078mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1100mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1130mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1145mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1152mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1160mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1192mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1212mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1216mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1220mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x520mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x538mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x554mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x616.2mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x616mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x620mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x630mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x662mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x666mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x670mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x682mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x690mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x698mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x702mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x710mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x712mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x722mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x730mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x732mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x734mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x750mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x760mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x770mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x772mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x776mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x803mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x818mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x821mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x826mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x829mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x830mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x832mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x836mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x842mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x876.9mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x877mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x891mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x900mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x922mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x930mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x950mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x976mm Panel
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x978mm Panel
24mm Ply Window 910mm Center 1220x2440mm: 24mm Ply Window 910mm Center 1...2...
24mm Ply Window 910mm Offset 1220 x 2440mm: 24mm Ply Window 910mm Offset ...
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NE-SE Corner Panel
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NW-SW Corner Panel
Mass Bamboo Corner Panel: Mass Bamboo Corner Panel Full Height NE-SE
Mass Bamboo Door Ope 900mm No Door: Mass Bamboo Door Ope 900mm No Door
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm
Mass Bamboo Double Window Ope Center 1820mm: Mass Bamboo Double Window O...e...
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1000mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1006mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1014mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1022mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1058mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1078mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1092mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1100mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1107mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1115mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1123mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1127mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1130mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1145mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1160mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1192mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1204mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1212mmx2440m
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1219mmx2440m

Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1220mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1228mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1232mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1260mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1274mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1284mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1286mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1305mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1334mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1340mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1352mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1375mmx2440mm
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Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1411mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1434mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1435mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1442mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1448mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1455mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 151mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1531mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1539mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1542.8mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1550.2mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1578mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1652mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1702mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1738mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1740mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1756mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1764mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1800mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1850mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1852mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1860mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1876mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1878mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mmx2440mm 2
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1910mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 191mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1932mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1941mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1942mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1944mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1946mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1950mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1954mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1973mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1988mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1991mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2002.2mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2023mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2033mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2038mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2048mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2049mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2050mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2056mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2064mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2111mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2196mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2372mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2380mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2440mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2484mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2492mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2760mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 290mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 350mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 462mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 488mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 535mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 538mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 543mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 551mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 556mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 559mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 616.2mmx2440mm
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 620mmx2440mm

Results per Revit Category, itemized by Family (continued)

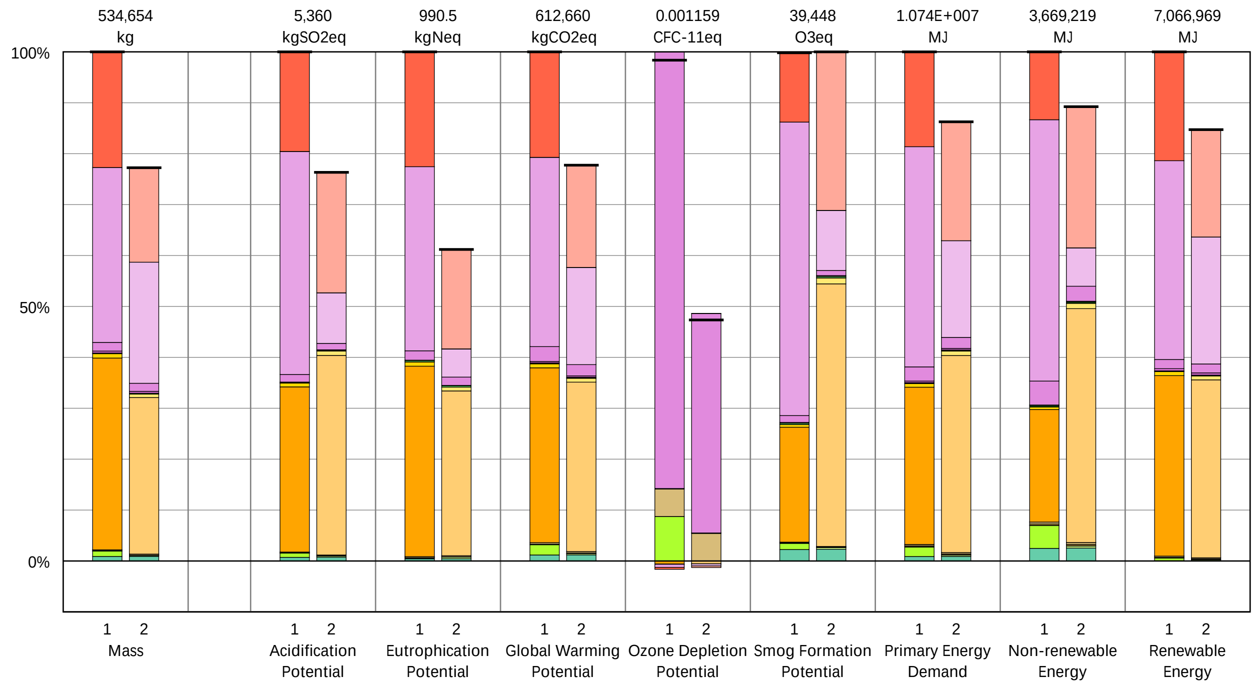
Legend (continued)

- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 640mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 648mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 670mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 682mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 696mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 700mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 710mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 750mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 772mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 814mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 822mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 830mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 842mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 876.9mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 877mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 896mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 930mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 950mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 958mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 978mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1220mmx732mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1320mmx732mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1490mmx732mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1530mmx732mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1610mmx732mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1990mmx732mm
- Mass Bamboo Window Ope Center 910mm: Mass Bamboo Window Ope Center 910mm
- Mass Bamboo Window Ope Offset 910mm: Mass Bamboo Window Ope Offset 910mm
- Mass Bamboo Window Ope Single Plus Half 1260mm: Mass Bamboo Window Ope Single...

Walls

- Cross Laminated Timber Mass 100mm
- Cross Laminated Timber Mass 188mm
- Cross Laminated Timber Mass 300
- Generic Bamboo Mass 100
- Generic Bamboo Mass 188mm
- Generic Bamboo Mass 300

Results per Revit Category, itemized by Tally Entry



Legend

Design Options

Option 1 - Mass Bamboo Panel

Option 2 - Plywood Hybrid Box (primary)

Curtain Panels

- Glazing, triple pane IGU

Curtain Wall Mullions

- Aluminum, extrusion
- Flooring, bamboo plank

Doors

- Domestic softwood
- Door frame, wood
- Door, interior, wood, MDF core, flush
- Stainless steel, hardware

Floors

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Roofs

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Stairs and Railings

- Aluminum, extrusion
- Flooring, engineered wood plank

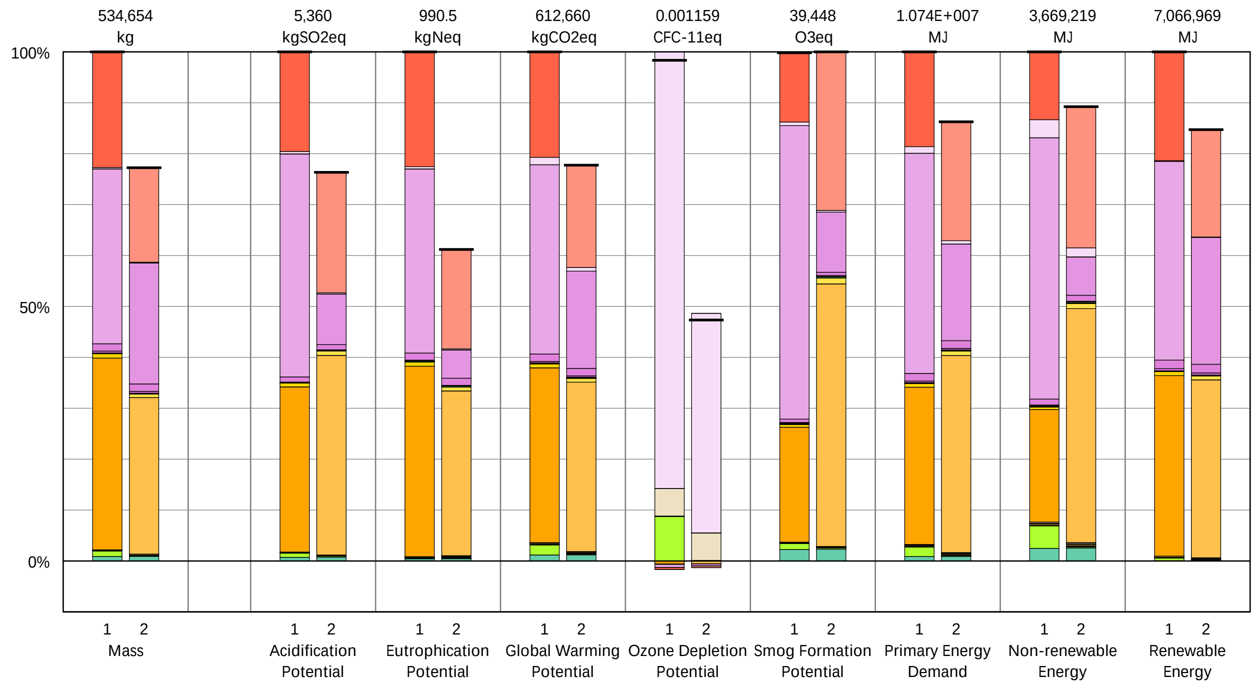
Structure

- Domestic softwood
- Door, interior, wood, MDF core, flush
- Flooring, bamboo plank
- Plywood, exterior grade
- Stainless steel, hardware

Walls

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Results per Revit Category, itemized by Material



Legend

Design Options

Option 1 - Mass Bamboo Panel

Option 2 - Plywood Hybrid Box (primary)

Curtain Panels

- Glazing, triple, insulated (argon), low-E

Curtain Wall Mullions

- Aluminum, extruded
- Flooring, bamboo plank
- Polyurethane floor finish, water-based
- Powder coating, metal stock
- Urethane adhesive

Doors

- Domestic softwood, US
- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Hardware, stainless steel
- None
- Stainless steel, door hardware, lever lock, interior, residential

Floors

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Roofs

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Stairs and Railings

- Aluminum, extruded
- Interior grade plywood, US
- None
- Polyurethane floor finish, water-based
- Powder coating, metal stock
- Veneer, hardwood

Structure

- Domestic softwood, US
- Door, interior, wood, MDF Core, flush
- Exterior grade plywood, US
- Flooring, bamboo plank
- Hardware, stainless steel
- None
- Stainless steel, door hardware, lever lock, interior, residential

Walls

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Calculation Methodology

Studied objects

The LCA results in the report represent either an analysis of a single building, or a comparative analysis of two or more building design options. The single building may represent the complete architectural, structural, and finish systems of a building or a subset of those systems, and it may be used to compare the relative contributions of building systems to environmental impacts and for comparative study with one or more reference buildings. The comparison of design options may represent a full building in various stages of the design process, or they may represent multiple schemes of a full or partial building that are being compared to one another across a range of evaluation criteria.

Functional unit and reference flow

The functional unit of the analysis is the usable floor space of the building under study. For a design option comparison of a partial building, the functional unit is the complete set of building systems that performs a given function. The reference flow is the amount of material required to produce a building, or portion thereof, designed according to the given goal and scope of the assessment, over the full life of the building. If operational energy is included in the assessment the reference flow also includes the electrical and thermal energy consumed on site over the life of the building. It is the responsibility of the modeler to assure that reference buildings or design options are functionally equivalent in terms of scope, size, and relevant performance. The expected life of the building has a default value of 60 years and can be modified by the model author.

System boundaries and delimitations

The analysis accounts for the full cradle-to-grave life cycle of the design options studied, including material manufacturing, maintenance and replacement, and eventual end-of-life (disposal, incineration, and/or recycling), including the materials and energy used across all life cycle stages. Optionally, the operational energy of the building can be included within the scope.

Architectural materials and assemblies include all materials required for the product’s manufacturing and use (including hardware, sealants, adhesives, coatings, and finishing, etc.) up to a 1% cut-off factor by mass with the exception of known materials that have high environmental impacts at low levels. In these cases, a 1% cut-off was implemented by impact.

Manufacturing includes cradle-to-gate manufacturing wherever possible. This includes raw material extraction and processing, intermediate transportation, and final manufacturing and assembly. Due to data limitations, however, some manufacturing steps have been excluded, such as the material and energy requirements for assembling doors and windows. The manufacturing scope is listed for each entry, detailing any specific inclusions or exclusions that fall outside of the cradle-to-gate scope.

Transportation of upstream raw materials or intermediate products to final manufacturing is generally included in the GaBi datasets utilized within this tool. Transportation requirements between the manufacturer and installation of the product, and at the end-of-life of the product, are excluded from this study.

Infrastructure (buildings and machinery) required for the manufacturing and assembly of building materials, as well as packaging materials, are not included and are considered outside the scope of assessment.

Maintenance and replacement encompasses the replacement of materials in accordance with the expected service life. This includes the end-of-life treatment of the existing products and cradle-to-gate manufacturing of the replacement products. The service life is specified separately for each product.

Operational energy treatment is based on the anticipated energy consumed at the building site over the lifetime of the building. Each energy dataset includes relevant upstream impacts associated with extraction of energy resources (e.g., coal, crude oil), refining, combustion, transmission, losses, and other associated factors. US electricity generation datasets are based on subregions from US EPA's eGRID2012 database v1.0, but adapted to account for imports and exports into these regions. These consumption mixes - unique to the GaBi databases - provide a more accurate reflection of impacts associated with electricity consumption.

End-of-life treatment is based on average US construction and demolition waste treatment methods and rates. This includes the relevant material collection rates for recycling, processing requirements for recycled materials, incineration rates, and landfilling rates. Along with processing requirements, the recycling of materials is modeled using an avoided burden approach, where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material. Incineration of materials includes credit for average US energy recovery rates. The impacts associated with landfilling are based on average material properties, such as plastic waste, biodegradable waste, or inert material. Specific end-of-life scenarios are detailed for each entry.

Data source and quality

Tally utilizes a custom designed LCA database that combines material attributes, assembly details, and engineering and architectural specifications with environmental impact data resulting from the collaboration between KieranTimberlake and PE INTERNATIONAL. LCA modeling was conducted in GaBi 6 using GaBi databases and in accordance with GaBi database and modeling principles.

Geography and date: The data used are intended to represent the US and the year 2013. Where representative data were unavailable, proxy data were used. The datasets used, their geographic region, and year of reference are listed for each entry. An effort was made to choose proxy datasets that are technologically consistent with the relevant entry.

Uncertainty in results can stem from both the data used and the application of the data. Data quality is judged by its precision (measured, calculated, or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological). The LCI data sets from the GaBi LCI databases have been used in LCA models worldwide in industrial and scientific applications, both as internal and critically reviewed and published studies. The uncertainty introduced by the use of any proxy data is reduced by using technologically, geographically, and/or temporally similar data. It is the responsibility of the modeler to apply the predefined material entries appropriately to the building under study.

Tally methodology is consistent with LCA standards ISO 14040-14044.

Glossary of LCA Terminology

Environmental Impact Categories

The following list provides a description of environmental impact categories reported according to the TRACI 2.1 characterization scheme. References: [Bare 2010, EPA 2012, Guinée 2001]

Acidification Potential (AP) — kg SO2 eq

A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline, and the deterioration of building materials.

Eutrophication Potential (EP) — kg N eq

Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.

Global Warming Potential (GWP) — kg CO2 eq

A measure of greenhouse gas emissions, such as CO2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health, and material welfare.

Ozone Depletion Potential (ODP) — kg CFC-11 eq

A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants.

Smog Formation Potential (SFP) — kg O3 eq

Ground level ozone is created by various chemical reactions, which occur between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in sunlight. Human health effects can result in a variety of respiratory issues including increasing symptoms of bronchitis, asthma, and emphysema. Permanent lung damage may result from prolonged exposure to ozone. Ecological impacts include damage to various ecosystems and crop damage. The primary sources of ozone precursors are motor vehicles, electric power utilities, and industrial facilities.

Primary Energy Demand (PED) — MJ (lower heating value)

A measure of the total amount of primary energy extracted from the earth. PED is expressed in energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.) and energy demand from renewable resources (e.g. hydropower, wind energy, solar, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account.

LCA Metadata

NOTES

The following list provides a summary of all materials and energy inputs present in the selected study. Materials are listed in alphabetical order along with a list of all Revit families and Tally entries in which they occur and any notes and system boundaries accompanying their database entries. The mass given here refers to the full life-cycle mass of material, including manufacturing and replacement.

Aluminum, extruded 5,621.2 kg

Used in the following Revit families:
1100mm 0.0 kg
Quad Corner Mullion: Quad Mullion 1 288.1 kg
Rectangular Mullion: 50 x 120mm 363.0 kg
Rectangular Mullion: 50 x 150mm 4,970.1 kg

Used in the following Tally entries:
Aluminum, extrusion

Description:
Extruded aluminum part

Life Cycle Inventory:
Aluminum, process energy

Manufacturing Scope:
Cradle to gate

End of Life Scope:
95% recovered (includes recycling, scrap preparation, and avoided burden credit)
5% landfilled (inert material)

Entry Source:
NA: Primary Aluminium Ingot AA (2011)
EU-27: Aluminium extrusion profile PE (2012)

Cross laminated timber (CrossLam) 327,353.0 kg

Used in the following Revit families:
CLT Timber 201,344.7 kg
Cross Laminated Timber CLT 4,582.3 kg
Cross Laminated Timber Mass 100mm 239.0 kg
Cross Laminated Timber Mass 188mm 2,241.5 kg
Cross Laminated Timber Mass 300 118,945.6 kg

Used in the following Tally entries:
Cross laminated timber (CrossLam / CLT)

Description:
PROXIED by LVL

Life Cycle Inventory:
43% PNW
57% SE
Proxied by LVL

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
US: Laminated veneer lumber, at plant, US PNW USLCI/PE (2009)
US: Laminated veneer lumber, at plant, US SE USLCI/PE (2009)

Domestic softwood, US 4,263.9 kg

Used in the following Revit families:
24mm Ply Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm P1,985.0 kg
IntSgl (7): 1010 x 2110mm 74.4 kg
IntSgl (7): 810 x 2110mm 128.8 kg
IntSgl (7): 910 x 2110mm 102.2 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm 1,973.6 kg

Used in the following Tally entries:
Domestic softwood

Description:
Dimensional lumber, sawn, planed, dried and cut for standard framing or planking

Life Cycle Inventory:
38% PNW
62% SE
Dimensional lumber

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Surfaced dried lumber, at planer mill, PNW USLCI/PE (2009)
US: Surfaced dried lumber, at planer mill, SE USLCI/PE (2009)

Door frame, wood, no door 279.1 kg

Used in the following Revit families:
IntSgl (7): 1010 x 2110mm 68.0 kg
IntSgl (7): 810 x 2110mm 117.7 kg
IntSgl (7): 910 x 2110mm 93.4 kg

Used in the following Tally entries:
Door frame, wood

Description:
Wood door frame

Life Cycle Inventory:
Dimensional lumber

Manufacturing Scope:
Cradle to gate, excludes hardware, jamnb, casing, sealant

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
DE: Wooden frame (EN15804 A1-A3) PE (2012)

Door, interior, wood, MDF Core, flush 17,360.9 kg

Used in the following Revit families:
24mm Ply Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm P7,733.9 kg
IntSgl (7): 1010 x 2110mm 523.0 kg
IntSgl (7): 810 x 2110mm 754.9 kg
IntSgl (7): 910 x 2110mm 659.7 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm 7,689.4 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Interior flush wood door with MDF core

Life Cycle Inventory:
12.2 kg/m² Wood, 0.052 m3/m3 MDF

Manufacturing Scope:
Cradle to gate, excludes assembly, frame, hardware, and adhesives

End of Life Scope:
14.5% wood products recovered (credited as avoided burden)
22% wood products incinerated with energy recovery
63.5% wood products landfilled (wood product waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)
DE: Wood fibre board PE (2012)

Exterior grade plywood, US 127,146.2 kg

Used in the following Revit families:
24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel S... 3.6 kg
24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel S... 59.3 kg
24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel S... 8.3 kg
24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel S... 70.6 kg
24mm Ply Balcony Half Panel 732 x 1220 A: 24mm Ply Balcony Half Pan... 2,885.9 kg
24mm Ply Balcony Half Panel 732 x 1220 A: 24mm Ply Balcony Half Pan... 20.5 kg
24mm Ply Corner Panel Adaptable 2440mm x Length x Length: 24mm Ply ... 947.2 kg
24mm Ply Corner Panel Half Adaptable 2440mm x Length x Length: 24mm... 1,453.4 kg
24mm Ply Door Ope Panel 2440x1220x128 NO Door A: 24mm Ply Door Ope ... 904.3 kg

LCA Metadata (continued)

24mm Ply Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm P...	16,149.8 kg
24mm Ply Level 8 Window 300 x 910mm Offset: 24mm Ply Level 8 Window...	374.6 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 120	40.6 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 122	13.7 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 132	28.9 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 147	15.6 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 151	63.4 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 160	16.5 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 163.2	50.3 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 191	113.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 214	431.4 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 221	84.2 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 222	21.1 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 223.1	63.7 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 228	64.7 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 230	86.9 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 231	87.2 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 241	67.7 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 248	23.1 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 251	93.2 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 255	70.8 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 259	23.9 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 260	95.9 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 264	72.8 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 270	24.7 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 272	99.4 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 282	25.6 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 310	415.3 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 320	909.8 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 322	28.6 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 330.2	233.5 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 331	409.5 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 334	294.7 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 342	421.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 355	124.1 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 358	125.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 432	73.5 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 72	29.9 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1000m...	245.4 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1014m...	662.3 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1022m...	250.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1036m...	84.3 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1058m...	85.9 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1078m...	87.2 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1100m...	2,663.5 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1130m...	363.5 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1145m...	367.7 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1152m...	1,478.5 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1160m...	371.9 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1192m...	380.8 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1212m...	483.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1216m...	96.9 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1220m...	63,340.4 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x520mm...	48.3 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x538mm...	99.2 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x554mm...	101.4 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x616.2...	550.5 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x616mm...	55.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x620mm...	55.3 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x630mm...	448.1 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x662mm...	116.5 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x666mm...	175.6 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x670mm...	235.2 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x682mm...	119.3 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x690mm...	180.6 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x698mm...	243.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x702mm...	61.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x710mm...	246.4 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x712mm...	123.5 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x722mm...	874.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x730mm...	63.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x732mm...	63.1 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x734mm...	632.7 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x750mm...	2,961.6 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x760mm...	130.2 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x770mm...	131.6 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x772mm...	395.5 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x776mm...	198.6 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x803mm...	204.2 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x818mm...	414.7 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x821mm...	624.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x826mm...	209.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x829mm...	139.8 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x830mm...	2,868.3 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x832mm...	280.4 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x836mm...	211.1 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x842mm...	849.6 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x876.9...	72.6 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x877mm...	73.2 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x891mm...	222.6 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x900mm...	149.7 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x922mm...	76.4 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x930mm...	153.9 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x950mm...	1,253.2 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x976mm...	80.1 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x978mm...	80.3 kg
24mm Ply Window 910mm Center 1220x2440mm: 24mm Ply Window 910mm Cen...	6,848.6 kg
24mm Ply Window 910mm Offset 1220 x 2440mm: 24mm Ply Window 910mm O...	5,343.1 kg

Used in the following Tally entries:
Plywood, exterior grade

Description:
Plywood, unfinished

Life Cycle Inventory:
33% PNW
67% SE
Plywood

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)

Flooring, bamboo plank — 451,852.7 kg

Used in the following Revit families:

Bamboo LVB	3,740.6 kg
Generic Bamboo Mass 100	195.1 kg
Generic Bamboo Mass 188mm	1,829.8 kg
Generic Bamboo Mass 300	97,176.2 kg
LVB Bamboo Floor	164,371.7 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NE-SE Corner Panel	789.8 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NW-SW Corner Panel	1,297.4 kg
Mass Bamboo Corner Panel: Mass Bamboo Corner Panel Full Height NE-SE	1,430.2 kg
Mass Bamboo Door Ope 900mm No Door: Mass Bamboo Door Ope 900mm No Door	1,219.1 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	15,892.0 kg
Mass Bamboo Double Window Ope Center 1820mm: Mass Bamboo Double Win...	6,600.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1000mm...	374.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1006mm...	125.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1014mm...	1,140.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1022mm...	127.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1058mm...	247.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1078mm...	134.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1092mm...	272.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1100mm...	549.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1107mm...	138.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1115mm...	278.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1123mm...	841.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1127mm...	396.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1130mm...	661.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1145mm...	429.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1160mm...	289.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1192mm...	595.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1204mm...	150.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1212mm...	1,211.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1219mm...	609.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1220mm...	65,842.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1228mm...	153.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1232mm...	307.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1260mm...	157.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1274mm...	318.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1284mm...	300.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1286mm...	150.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1305mm...	152.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1334mm...	156.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1340mm...	669.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1352mm...	475.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1375mm...	171.8 kg

LCA Metadata (continued)

Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1383mm…	518.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1411mm…	1,939.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1434mm…	4,299.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1435mm…	179.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1442mm…	1,801.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1448mm…	361.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1455mm…	181.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 151mmx…	70.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1531mm…	2,486.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1539mm…	1,922.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1542.8…	192.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1550.2…	1,162.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1578mm…	197.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1652mm…	387.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1702mm…	637.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1738mm…	217.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1740mm…	652.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1756mm…	438.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1764mm…	440.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1800mm…	224.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1850mm…	1,733.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1852mm…	231.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1860mm…	464.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1876mm…	234.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1878mm…	703.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mm…	940.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mm…	470.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1910mm…	1,431.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 191mmx…	23.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1932mm…	482.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1941mm…	242.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1942mm…	3,153.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1944mm…	242.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1946mm…	486.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1950mm…	243.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1954mm…	1,952.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1973mm…	493.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1988mm…	745.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1991mm…	497.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2002.2…	250.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2023mm…	758.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2033mm…	508.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2038mm…	1,527.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2048mm…	255.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2049mm…	256.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2050mm…	256.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2056mm…	513.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2064mm…	257.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2111mm…	989.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2196mm…	274.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2372mm…	4,148.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2380mm…	594.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2440mm…	1,143.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2484mm…	1,861.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2492mm…	1,245.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2760mm…	323.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 290mmx…	36.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 350mmx…	164.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 462mmx…	57.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 488mmx…	61.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 535mmx…	133.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 538mmx…	134.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 543mmx…	203.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 551mmx…	68.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 556mmx…	138.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 559mmx…	69.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 616.2m…	769.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 620mmx…	77.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 640mmx…	399.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 648mmx…	81.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 670mmx…	334.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 682mmx…	159.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 696mmx…	86.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 700mmx…	349.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 710mmx…	266.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 750mm…	4,216.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 772mmx…	289.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 814mmx…	101.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 822mmx…	410.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 830mm…	2,695.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 842mmx…	631.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 876.9m…	219.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 877mmx…	109.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 896mmx…	111.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 930mmx…	232.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 950mm…	1,424.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 958mmx…	359.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 978mmx…	114.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1220mm…	3,475.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1320mm…	46.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1490mm…	446.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1530mm…	53.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1610mm…	422.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1990mm…	69.9 kg
Mass Bamboo Window Ope Center 910mm: Mass Bamboo Window Ope Center…	9,461.2 kg
Mass Bamboo Window Ope Offset 910mm: Mass Bamboo Window Ope Offset…	1,320.2 kg
Mass Bamboo Window Ope Single Plus Half 1260mm: Mass Bamboo Window …	986.3 kg
Quad Corner Mullion: Quad Mullion Bamboo	43.2 kg
Rectangular Mullion: 50 x 120mm Bamboo	53.7 kg
Rectangular Mullion: 50 x 150mm Bamboo	741.9 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Bamboo plank flooring

Life Cycle Inventory:
90% Bamboo, 10% phenol formaldehyde

Manufacturing Scope:
Cradle to gate for raw material only, includes transportation from China and estimate for material processing neglects materials for installation

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
CN: Bamboo (estimation) PE (2012)
GLO: Bulk commodity carrier PE (2012)
US: Heavy fuel oil at refinery (0.3wt.% S) PE (2010)
CN: Electricity grid mix PE (2010)
DE: Phenol formaldehyde resin PE (2012)

Glazing, triple, insulated (argon), low-E — 9,621.3 kg

Used in the following Revit families:

System Panel: Glazed	9,621.3 kg

Used in the following Tally entries:
Glazing, triple pane IGU

Description:
Glazing, triple, insulated (argon filled), 1/8" float glass, low-E, inclusive of argon gas fill, sealant, and spacers

Life Cycle Inventory:
32.4 kg/m² glass
Argon filled, 0.15 kg/m² low-e coating

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Insulation glass compound (3 panes) PE (2012)

Hardware, stainless steel — 9.1 kg

Used in the following Revit families:

24mm Ply Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm P…	0.6 kg
IntSgl (7): 1010 x 2110mm	2.1 kg
IntSgl (7): 810 x 2110mm	3.1 kg
IntSgl (7): 910 x 2110mm	2.7 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	0.6 kg

Used in the following Tally entries:
Stainless steel, hardware

Description:
Finished, cast stainless steel entry applicable for door, window or other accessory hardware

LCA Metadata (continued)

Life Cycle Inventory:
Stainless steel

Manufacturing Scope:
Cradle to gate

End of Life Scope:
98% recovered (product has 58.1% scrap input while remainder is processed and credited as avoided burden)
2% landfilled (inert material)

Entry Source:
RER: Stainless steel Quarto plate (304) Eurofer (2008)
DE: Steel cast part machining PE (2012)
US: Electricity grid mix PE (2010)
RER: Stainless steel flat product (304) - value of scrap Eurofer (2008)

Interior grade plywood, US	1,023.1 kg
Used in the following Revit families:	
Stair	1,023.1 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Plywood, unfinished

Life Cycle Inventory:
33% PNW
67% SE
Plywood
Proxied by exterior grade plywood

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)

None	0.0 kg
Used in the following Revit families:	
24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel S...	0.0 kg
24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel S...	0.0 kg
24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel S...	0.0 kg
24 mm Ply Balcony Half Panel Single: 24 mm Ply Balcony Half Panel S...	0.0 kg
24mm Ply Balcony Half Panel 732 x 1220 A: 24mm Ply Balcony Half Pan...	0.0 kg
24mm Ply Balcony Half Panel 732 x 1220 A: 24mm Ply Balcony Half Pan...	0.0 kg
24mm Ply Corner Panel Adaptable 2440mm x Length x Length: 24mm Ply ...	0.0 kg
24mm Ply Corner Panel Half Adaptable 2440mm x Length x Length: 24mm...	0.0 kg
24mm Ply Door Ope Panel 2440x1220x128 NO Door A: 24mm Ply Door Ope ...	0.0 kg
24mm Ply Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm P...	0.0 kg
24mm Ply Level 8 Window 300 x 910mm Offset: 24mm Ply Level 8 Window...	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 120	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 122	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 132	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 147	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 151	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 160	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 163.2	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 191	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 214	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 221	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 222	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 223.1	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 228	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 230	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 231	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 241	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 248	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 251	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 255	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 259	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 260	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 264	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 270	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 272	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 282	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 310	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 320	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 322	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 330.2	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 331	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 334	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 342	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 355	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 358	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 432	0.0 kg
24mm Ply Single Box 128 x Width: 24mm Ply Single Box 128 x 72	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1000m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1014m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1022m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1036m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1058m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1078m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1100m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1130m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1145m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1152m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1160m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1192m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1212m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1216m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x1220m...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x520mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x538mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x554mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x616.2...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x616mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x620mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x630mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x662mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x666mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x670mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x682mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x690mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x698mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x702mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x710mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x712mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x722mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x730mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x732mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x734mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x750mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x760mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x770mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x772mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x776mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x803mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x818mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x821mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x826mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x829mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x830mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x832mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x836mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x842mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x876.9...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x877mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x891mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x900mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x922mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x930mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x950mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x976mm...	0.0 kg
24mm Ply Standard 2440x1220mm Panel A: 24mm Ply Standard 2440x978mm...	0.0 kg
24mm Ply Window 910mm Center 1220x2440mm: 24mm Ply Window 910mm Ce	0.0 kg
24mm Ply Window 910mm Offset 1220 x 2440mm: 24mm Ply Window 910mm O	0.0 kg
Bamboo LVB	0.0 kg
CLT Timber	0.0 kg
Cross Laminated Timber CLT	0.0 kg
Cross Laminated Timber Mass 100mm	0.0 kg
Cross Laminated Timber Mass 188mm	0.0 kg
Cross Laminated Timber Mass 300	0.0 kg
Generic Bamboo Mass 100	0.0 kg
Generic Bamboo Mass 188mm	0.0 kg
Generic Bamboo Mass 300	0.0 kg
IntSgl (7): 1010 x 2110mm	0.0 kg
IntSgl (7): 810 x 2110mm	0.0 kg

LCA Metadata (continued)

IntSgl (7): 910 x 2110mm	0.0 kg
LVB Bamboo Floor	0.0 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NE-SE Corner Panel	0.0 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NW-SW Corner Panel	0.0 kg
Mass Bamboo Corner Panel: Mass Bamboo Corner Panel Full Height NE-SE	0.0 kg
Mass Bamboo Door Ope 900mm No Door: Mass Bamboo Door Ope 900mm No Door	0.0 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	0.0 kg
Mass Bamboo Double Window Ope Center 1820mm: Mass Bamboo Double Win...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1000mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1006mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1014mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1022mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1058mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1078mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1092mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1100mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1107mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1115mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1123mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1127mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1130mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1145mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1160mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1192mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1204mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1212mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1219mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1220mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1228mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1232mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1260mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1274mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1284mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1286mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1305mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1334mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1340mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1352mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1375mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1383mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1411mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1434mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1435mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1442mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1448mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1455mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 151mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1531mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1539mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1542.8...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1550.2...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1578mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1652mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1702mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1738mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1740mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1756mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1764mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1800mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1850mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1852mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1860mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1876mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1878mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1910mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 191mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1932mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1941mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1942mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1944mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1946mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1950mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1954mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1973mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1988mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1991mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2002.2...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2023mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2033mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2038mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2048mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2049mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2050mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2056mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2064mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2111mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2196mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2372mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2380mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2440mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2484mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2492mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 2760mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 290mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 350mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 462mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 488mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 535mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 538mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 543mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 551mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 556mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 559mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 616.2m...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 620mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 640mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 648mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 670mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 682mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 696mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 700mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 710mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 750mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 772mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 814mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 822mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 830mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 842mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 876.9m...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 877mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 896mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 930mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 950mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 958mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 978mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1220mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1320mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1490mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1530mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1610mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1990mm...	0.0 kg
Mass Bamboo Window Ope Center 910mm: Mass Bamboo Window Ope Center ...	0.0 kg
Mass Bamboo Window Ope Offset 910mm: Mass Bamboo Window Ope Offset ...	0.0 kg
Mass Bamboo Window Ope Single Plus Half 1260mm: Mass Bamboo Window ...	0.0 kg
Stair	0.0 kg

Used in the following Tally entries:
- Cross laminated timber (CrossLam / CLT)
- Domestic softwood
- Door, interior, wood, MDF core, flush
- Flooring, bamboo plank
- Flooring, engineered wood plank
- Plywood, exterior grade

Description:
This entry is a placeholder, for use in cases when there is "no" finish, or "no added material designated.

Manufacturing Scope:
NA

Entry Source:
None

Polyurethane floor finish, water-based — 203.7 kg

Used in the following Revit families:

Quad Corner Mullion: Quad Mullion Bamboo	0.0 kg
Rectangular Mullion: 50 x 120mm Bamboo	0.0 kg
Rectangular Mullion: 50 x 150mm Bamboo	0.3 kg
Stair	203.3 kg

Used in the following Tally entries:
- Flooring, bamboo plank

LCA Metadata (continued)

Flooring, engineered wood plank

Description:
Water-based polyurethane wood stain, inclusive of catalyst

Life Cycle Inventory:
97.7% stain (50% water, 35% polyurethane dispersions, 5% dipropylene glycol dimethyl ether, 5% tri-butoxyethyl phosphate, 5% dipropylene glycol methyl ether), 2.3% catalyst (75% polyfunctional aziridine, 25% 2-propoxyethanol)
24.5% NMVOC emissions during application

Manufacturing Scope:
Cradle to gate, including emissions during application

End of Life Scope:
26.7% solids to landfill (plastic waste)

Entry Source:
DE: Ethylene glycol butyl ether PE (2012)
US: Epichlorohydrin (by product calcium chloride, hydrochloric acid) PE (2012)
DE: Propylenglycolmonomethylether (Methoxypropanol) PGME PE (2012)
US: Tap water from groundwater PE (2012)
DE: Polyurethane (copolymer-component) (estimation from TPU adhesive) PE (2012)
US: Electricity grid mix PE (2010)

Powder coating, metal stock 90.2 kg

Used in the following Revit families:

1100mm	72.5 kg
Quad Corner Mullion: Quad Mullion 1	0.5 kg
Rectangular Mullion: 50 x 120mm	1.2 kg
Rectangular Mullion: 50 x 150mm	16.0 kg

Used in the following Tally entries:
Aluminum, extrusion

Description:
Powder coating, for metal stock

Manufacturing Scope:
Cradle to gate, including application

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Application top coat powder (aluminium) PE (2012)
DE: Coating powder (industry
outside
red) PE (2012)

Stainless steel, door hardware, lever lock, interior, residential 2,307.0 kg

Used in the following Revit families:

24mm Ply Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm P...	712.2 kg
IntSgl (7): 1010 x 2110mm	48.2 kg
IntSgl (7): 810 x 2110mm	69.5 kg
IntSgl (7): 910 x 2110mm	60.8 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	1,416.3 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Stainless steel door fitting (hinges and lockset) for use on residential interior door assemblies.

Life Cycle Inventory:
Door hinges 0.622 kg/part, Battalion Lever Lockset, Light Duty, Privacy 0.70 kg/part

Manufacturing Scope:
Cradle to gate, including disposal of packaging.

End of Life Scope:
90% collection rate
remaining 10% deposited in the LCA model without recycling
material recycling efficiency dependant on the metal (89% steel, 90.2% aluminum, stainless steel 83%, zinc 91%, brass 94%)
Plastic components incinerated resulting in credits for electricity and thermal energy

Entry Source:
DE: Fitting stainless steel - FSB (2009)

Urethane adhesive 190.1 kg

Used in the following Revit families:

Quad Corner Mullion: Quad Mullion Bamboo	5.1 kg
Rectangular Mullion: 50 x 120mm Bamboo	13.3 kg
Rectangular Mullion: 50 x 150mm Bamboo	171.8 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Urethane adhesive for use with flooring and wall coverings.

Life Cycle Inventory:
50% limestone, 13% lime, 30% polyurethane, 1.5% stearic acid, 5% Methylene bis(phenylisocyanate) (MDI)
1.3% NMVOC emissions

Manufacturing Scope:
Cradle to gate, plus emissions during application

End of Life Scope:
98.7% solids to landfill (plastic waste)

Entry Source:
US: Limestone flour (5mm) PE (2012)
DE: Polyurethane (copolymer-component) (estimation from TPU adhesive) PE (2012)
US: Lime (CaO) calcination PE (2012)
US: Methylene diisocyanate (MDI) PE (2012)
DE: Stearic acid PE (2012)
US: Electricity grid mix PE (2010)

Veneer, hardwood 307.1 kg

Used in the following Revit families:

Stair	307.1 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Hardwood veneer

Life Cycle Inventory:
43% PNW
57% SE
veneer

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% landfilled (biodegradable waste)

Entry Source:
US: Dry veneer, at plywood plant, PNW USLCI/PE (2009)
US: Dry veneer, at plywood plant, SE USLCI/PE (2009)

Stadthaus, Murray Grove

Hybrid Building 128mm Diaphram and Mass Bamboo v CLT

03/03/2016

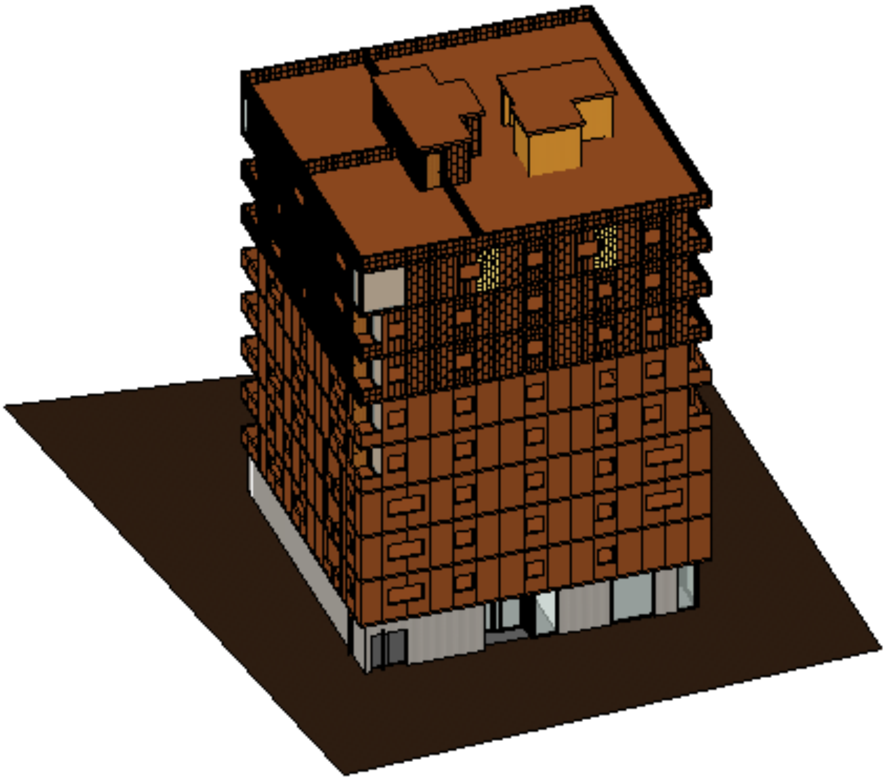


Table of Contents

Report Summary

Created with Tally
Non-commercial Version 2014.06.17.01

Author : Philip Kavanagh
Company : Dublin Institute of Technology
Date : 03/03/2016

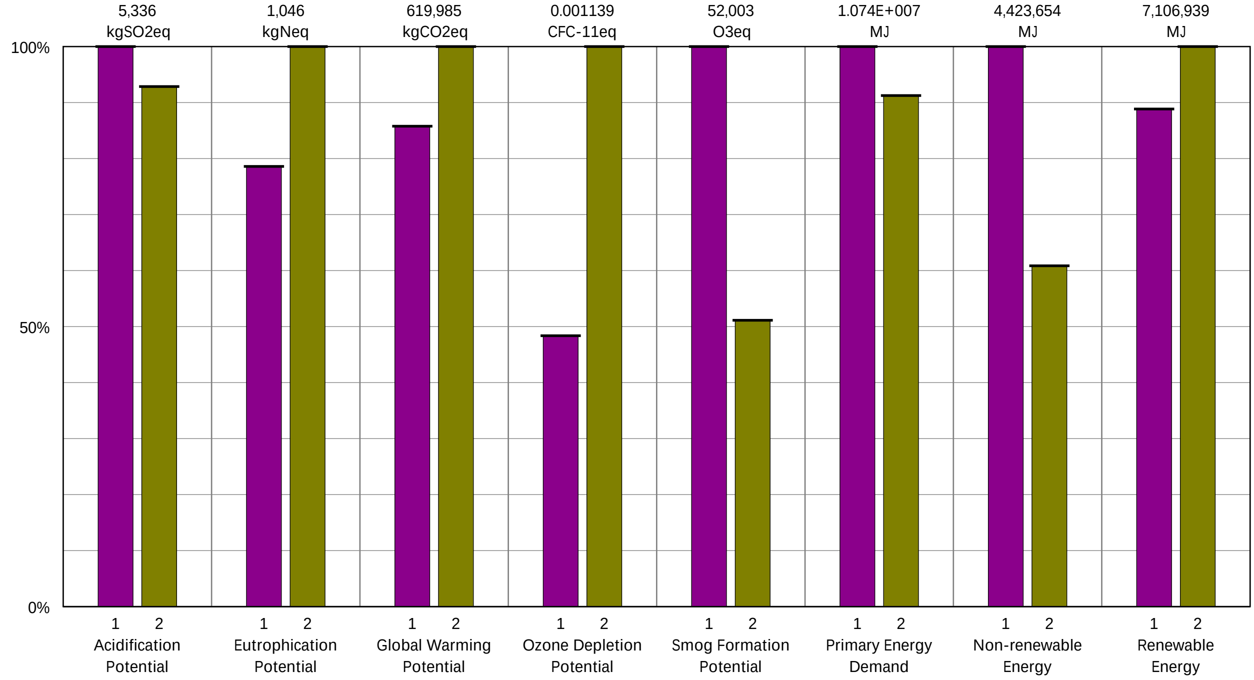
Project : Stadthaus, Murray Grove
Location : London, England
Gross Area : 2782.998 m²
Building Life : 50

Scope : Cradle-to-Grave, exclusive of operational energy

Goal of Assessment :
To determine the global warming potential, through life cycle analysis, of laminated veneer bamboo diaphragm panel construction over the seection of cross laminated timber panels for use in mid to high rise residential accommodation.

Object of Study

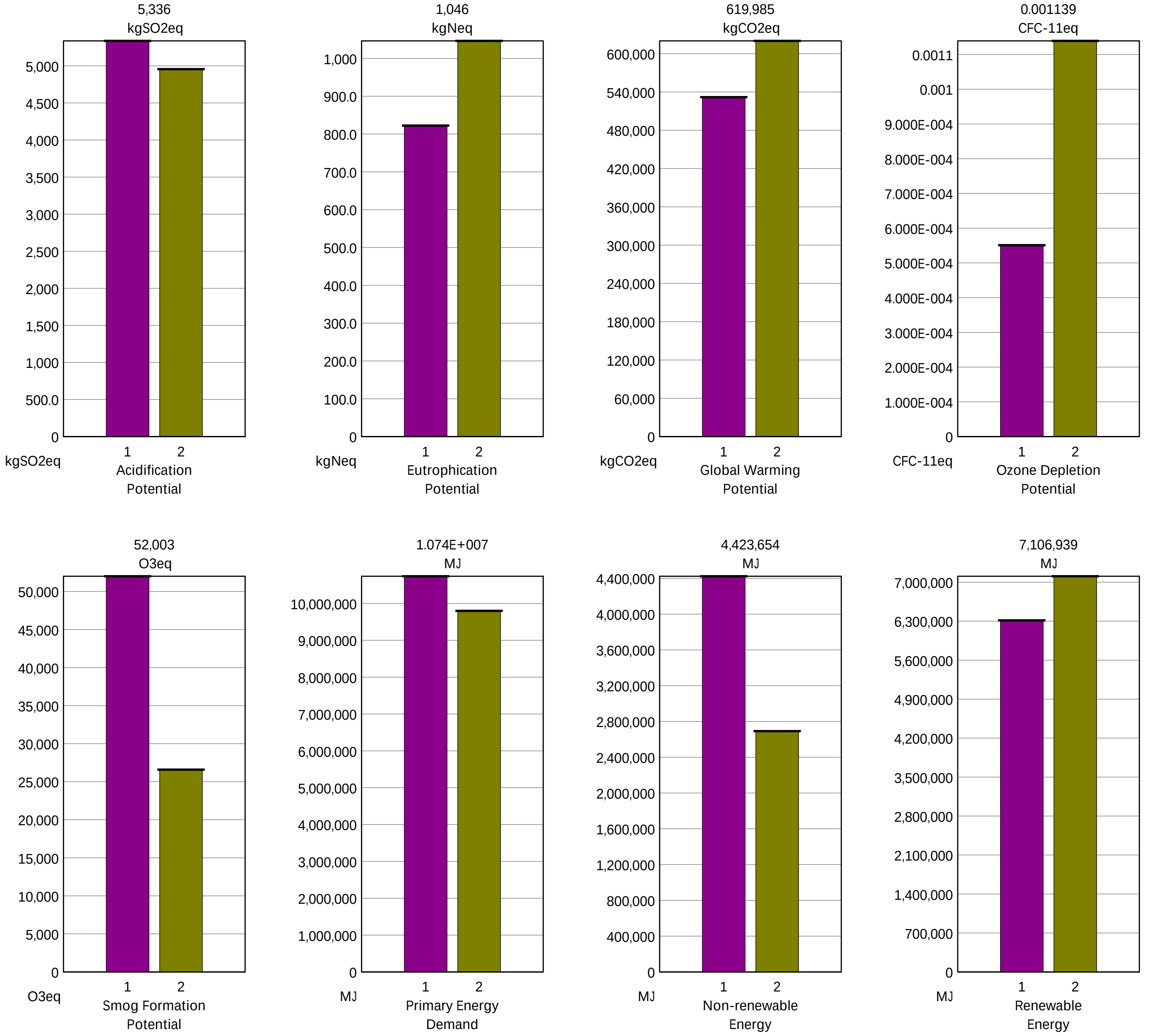
Design options set 'Option Set 1'
Bamboo LVB Hybrid Building Mass and LVB Panels (primary)
Cross Laminated Timber



Legend

Design Options
Bamboo LVB Hybrid Building Mass and LVB Panels (primary)
Cross Laminated Timber

Report Summary (continued)



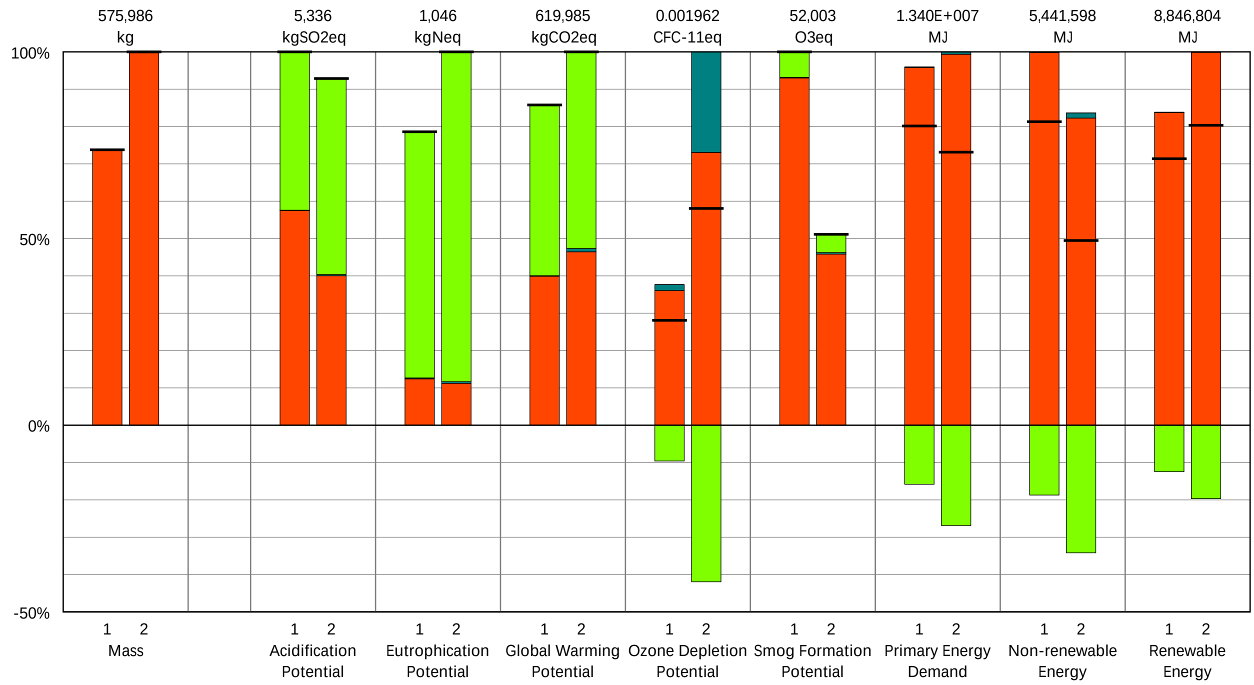
Legend

Design Options

Bamboo LVB Hybrid Building Mass and LVB Panels (primary)

Cross Laminated Timber

Results per Life Cycle Stage



Legend

Net value (impacts + credits)

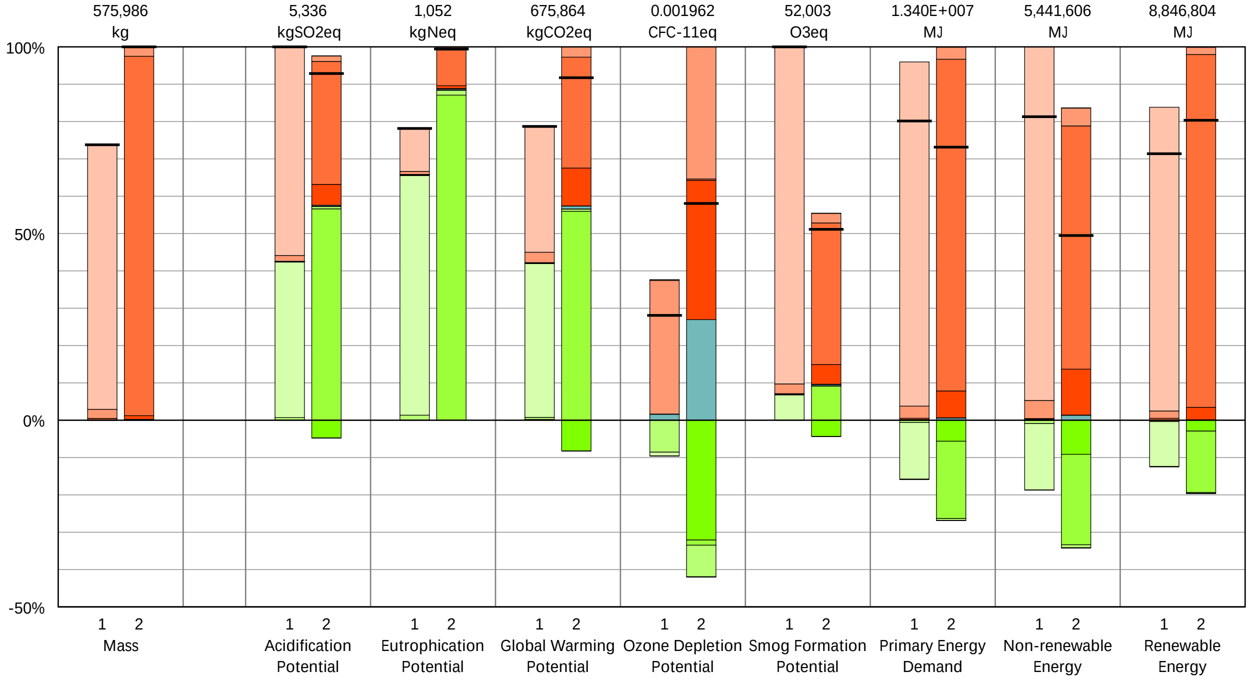
Design Options

Option 1 - Bamboo LVB Hybrid Building Mass and LVB Panels (primary)
Option 2 - Cross Laminated Timber

Life Cycle Stages

Manufacturing
Maintenance and Replacement
End of Life

Results per Life Cycle Stage, itemized by CSI Division



Legend

Net value (impacts + credits)

Design Options

Option 1 - Bamboo LVB Hybrid Building Mass and LVB Panels (primary)
Option 2 - Cross Laminated Timber

Manufacturing

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

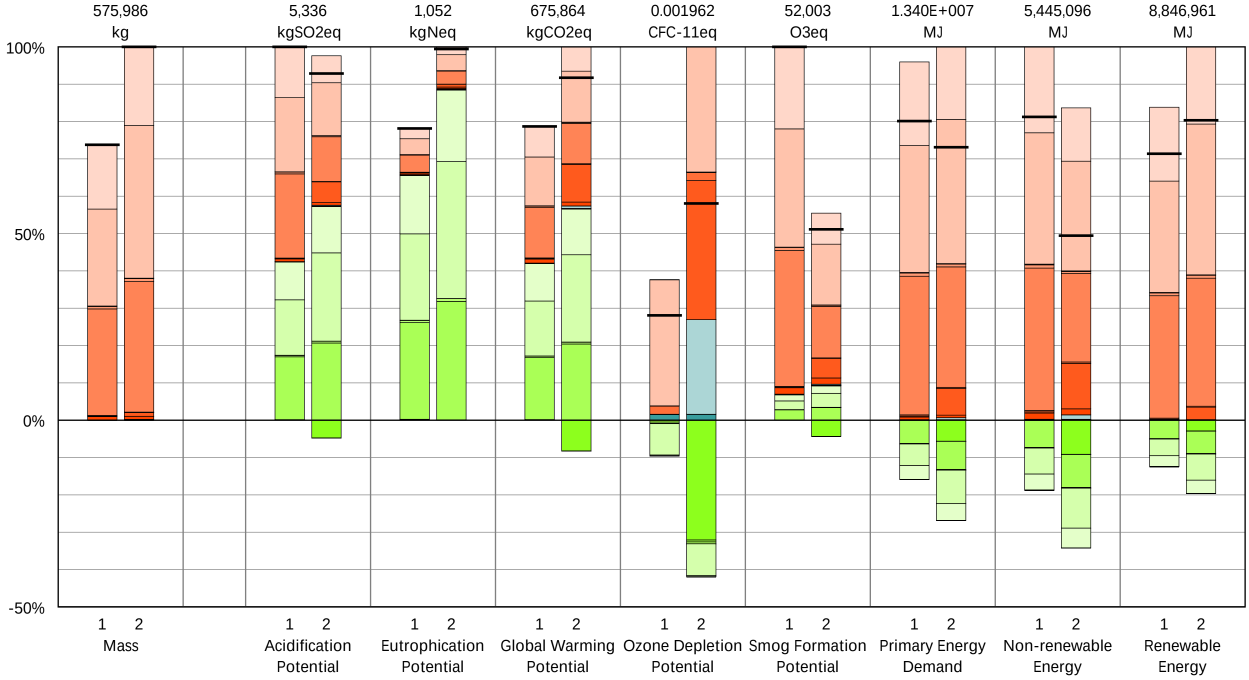
Maintenance and Replacement

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

End of Life

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

Results per Life Cycle Stage, itemized by Revit Category



Legend

Net value (impacts + credits)

Design Options

Option 1 - Bamboo LVB Hybrid Building Mass and LVB Panels (primary)

Option 2 - Cross Laminated Timber

Manufacturing

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

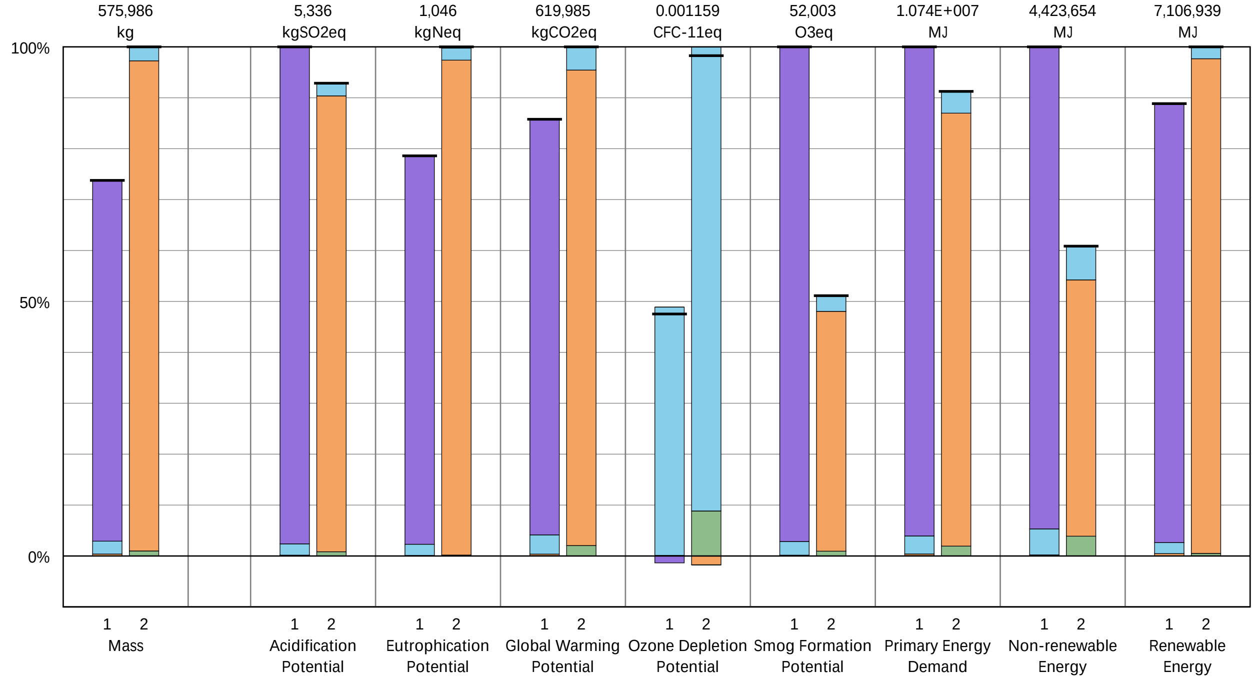
Maintenance and Replacement

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

End of Life

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per CSI Division



Legend

Design Options

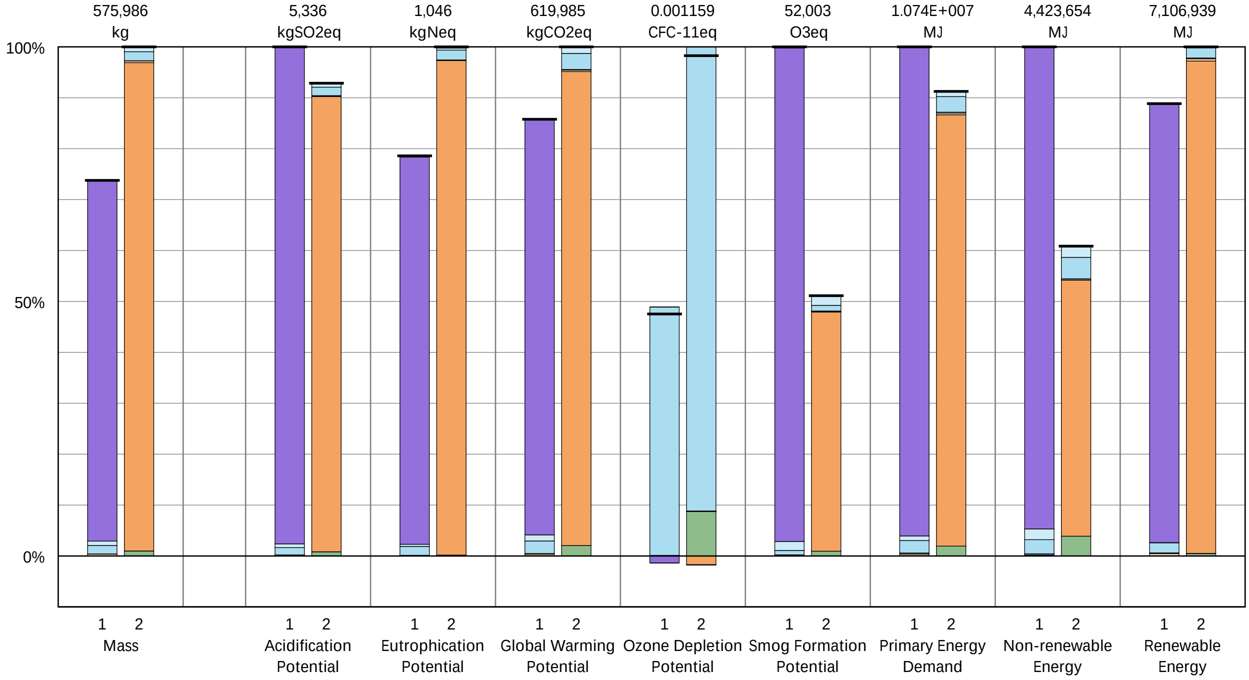
Option 1 - Bamboo LVB Hybrid Building Mass and LVB Panels (primary)

Option 2 - Cross Laminated Timber

CSI Divisions

- 05 - Metals
- 06 - Wood/Plastics/Composites
- 08 - Openings and Glazing
- 09 - Finishes

Results per CSI Division, itemized by Tally Entry



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Building Mass and LVB Panels (primary)

Option 2 - Cross Laminated Timber

05 - Metals

- Aluminum, extrusion
- Stainless steel, hardware

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam / CLT)
- Domestic softwood

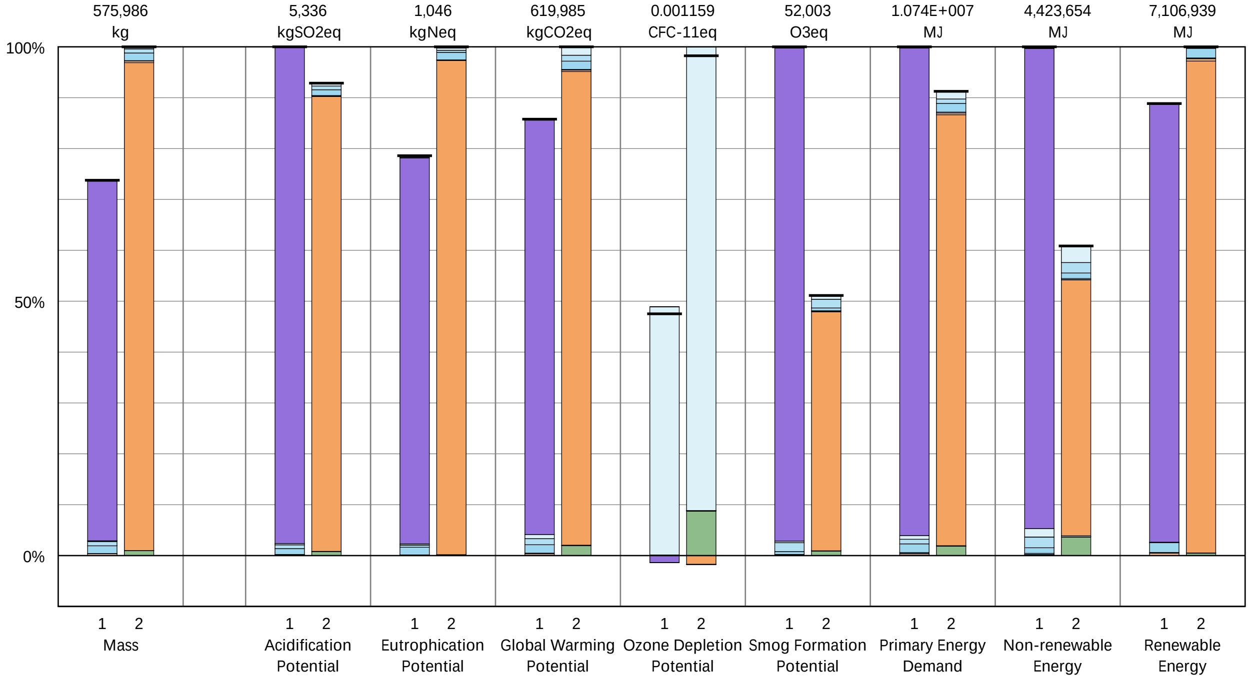
08 - Openings and Glazing

- Door frame, wood
- Door, interior, wood, MDF core, flush
- Glazing, triple pane IGU

09 - Finishes

- Flooring, bamboo plank
- Flooring, engineered wood plank

Results per CSI Division, itemized by Material



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Building Mass and LVB Panels (primary)

Option 2 - Cross Laminated Timber

05 - Metals

- Aluminum, extruded
- Hardware, stainless steel
- Powder coating, metal stock

06 - Wood/Plastics/Composites

- Cross laminated timber (CrossLam)
- Domestic softwood, US
- None

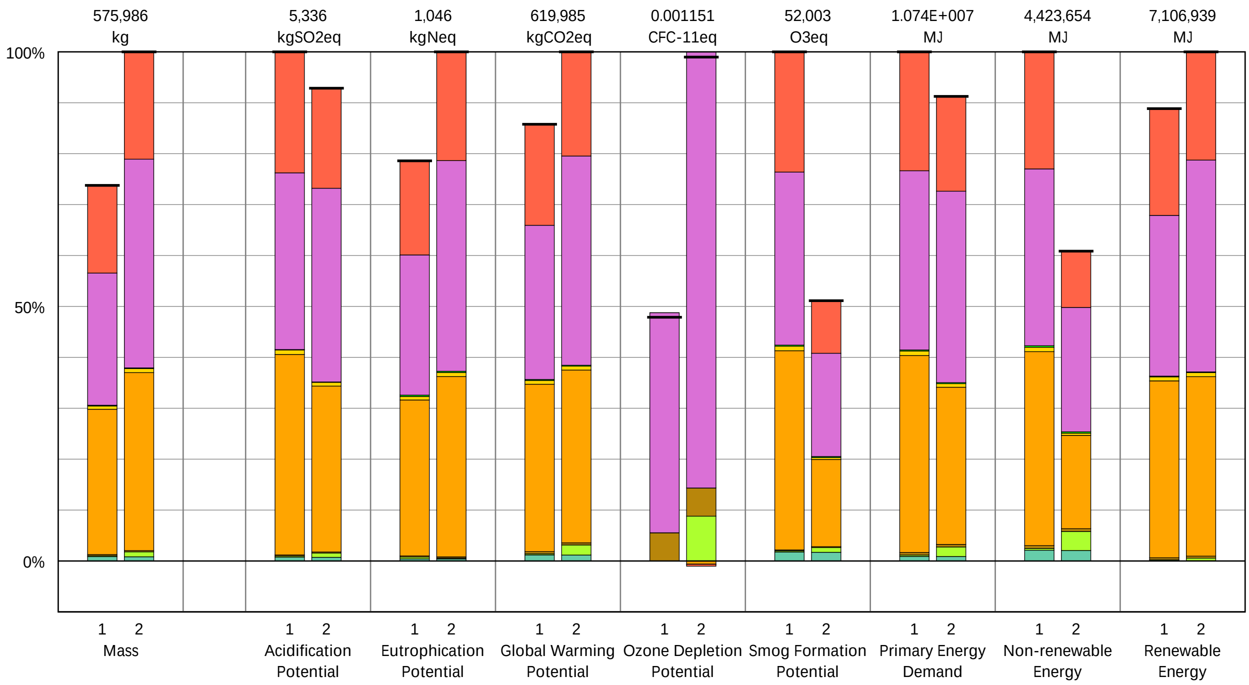
08 - Openings and Glazing

- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Glazing, triple, insulated (argon), low-E
- None
- Stainless steel, door hardware, lever lock, interior, residential

09 - Finishes

- Flooring, bamboo plank
- Interior grade plywood, US
- None
- Polyurethane floor finish, water-based
- Urethane adhesive
- Veneer, hardwood

Results per Revit Category



Legend

Design Options

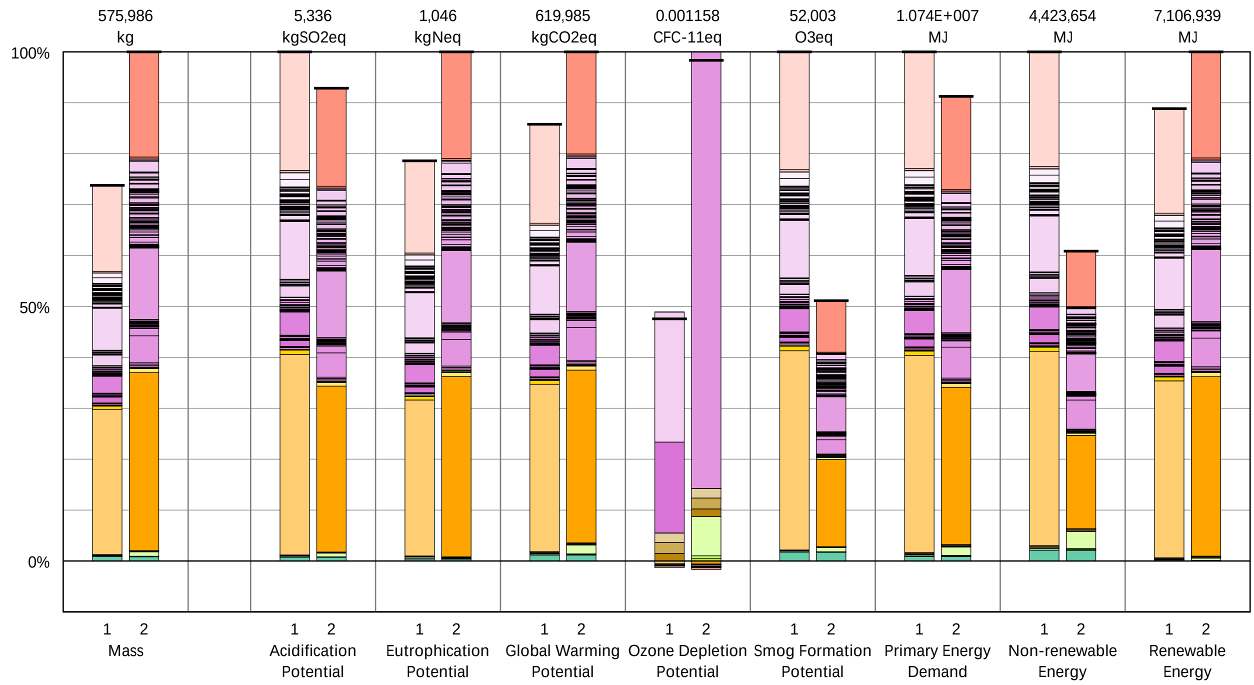
Option 1 - Bamboo LVB Hybrid Building Mass and LVB Panels (primary)

Option 2 - Cross Laminated Timber

Revit Categories

- Curtain Panels
- Curtain Wall Mullions
- Doors
- Floors
- Roofs
- Stairs and Railings
- Structure
- Walls

Results per Revit Category, itemized by Family



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Building Mass and LVB Panels (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- System Panel: Glazed

Curtain Wall Mullions

- Quad Corner Mullion: Quad Mullion 1
- Quad Corner Mullion: Quad Mullion Bamboo
- Rectangular Mullion: 50 x 120mm
- Rectangular Mullion: 50 x 120mm Bamboo
- Rectangular Mullion: 50 x 150mm
- Rectangular Mullion: 50 x 150mm Bamboo

Doors

- IntSgl (7): 1010 x 2110mm
- IntSgl (7): 810 x 2110mm
- IntSgl (7): 910 x 2110mm

Floors

- CLT Timber
- LVB Bamboo Floor

Roofs

- Bamboo LVB
- Cross Laminated Timber CLT

Stairs and Railings

- 1100mm
- Stair

Structure

- 24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel Single 100mm
- 24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel Single 270mm
- 24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel Single 310mm
- 24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel Single 390mm
- 24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Panel 732 x 1...
- 24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Panel 732 x 762
- 24mm LVB Corner Panel Half Adaptable 2440mm x Length x Length: 24mm LVB Corne
- 24mm LVB Door Ope Panel 2440x1220x128 NO Door A: 24mm LVB Door Ope Panel 2
- 24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm LVB Door Op...
- 24mm LVB Level 8 Window 300 x 910mm Offset: 24mm LVB Level 8 Window 300 x 910...
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 120
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 122
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 132
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- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 160
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 191
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 214
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 221
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 228
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 231
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 241
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 248
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 255
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 260
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 310
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 320
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 330.2
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 331
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 334
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 342
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 355
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 358
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 432
- 24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 72
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1014mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1058mm Panel
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- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1160mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1192mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1212mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1216mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1220mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x520mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x538mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x554mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616.2mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x620mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x630mm Panel

Results per Revit Category, itemized by Family (continued)

Legend (continued)

- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x662mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x666mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x670mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x682mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x698mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x702mm Panel
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- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x730mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x734mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x750mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x772mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x776mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x821mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x826mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x830mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x836mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x842mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x891mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x900mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x930mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x950mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x976mm Panel
- 24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x978mm Panel
- 24mm LVB Window 910mm Offset 1220 x 2440mm: 24mm LVB Window 910mm Offse…
- 24mm Window 910mm Center 1220x2440mm: 24mm Window 910mm Center 1220x2…
- CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel
- CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel
- CLT Corner Panel: CLT Corner Panel Full Height NE-SE
- CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door
- CLT Door Ope 900mm: CLT Door Ope 900mm
- CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1820mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1006mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1014mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1078mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1305mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1334mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1340mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1352mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1375mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1383mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1411mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1434mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1435mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1442mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1448mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1455mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 151mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1539mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1542.8mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1578mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1652mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1764mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1800mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1850mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1852mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1860mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1876mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1878mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm 2
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1910mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1932mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1941mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1988mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 1991mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2002.2mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2033mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2038mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2372mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2380mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 2440mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 290mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 350mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 462mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 488mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 535mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 543mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 877mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 930mmx2440mm
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- CLT Full Panel 1220mmx2440mm: CLT Full Panel 958mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Full Panel 978mmx2440mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1220mmx732mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1320mmx732mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1490mmx732mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1530mmx732mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1610mmx732mm
- CLT Full Panel 1220mmx2440mm: CLT Half Panel 1990mmx732mm
- CLT Window Ope Center 910mm: CLT Window Ope Center 910mm
- CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm

Results per Revit Category, itemized by Family (continued)

Legend (continued)

- CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus Half 1260mm
- Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NE-SE Corner Panel
- Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NW-SW Corner Panel
- Mass Bamboo Corner Panel: Mass Bamboo Corner Panel Full Height NE-SE
- Mass Bamboo Door Ope 900mm No Door: Mass Bamboo Door Ope 900mm No Door
- Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1000mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1014mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1022mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1036mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1078mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1100mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1130mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1145mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1152mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1160mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1192mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1212mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1220mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1286mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1340mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1352mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1383mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1411mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1434mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1435mmx2440mm
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- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1539mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1542.8mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1550.2mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1554mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1562mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1652mmx2440mm
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- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1738mmx2440mm
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- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1942mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1954mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 282mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 342mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 535mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 543mmx2440mm
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- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 616.2mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 640mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 666mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 670mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 682mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 690mmx2440mm
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- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 772mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 776mmx2440mm
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- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 818mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 821mmx2440mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 826mmx2440mm
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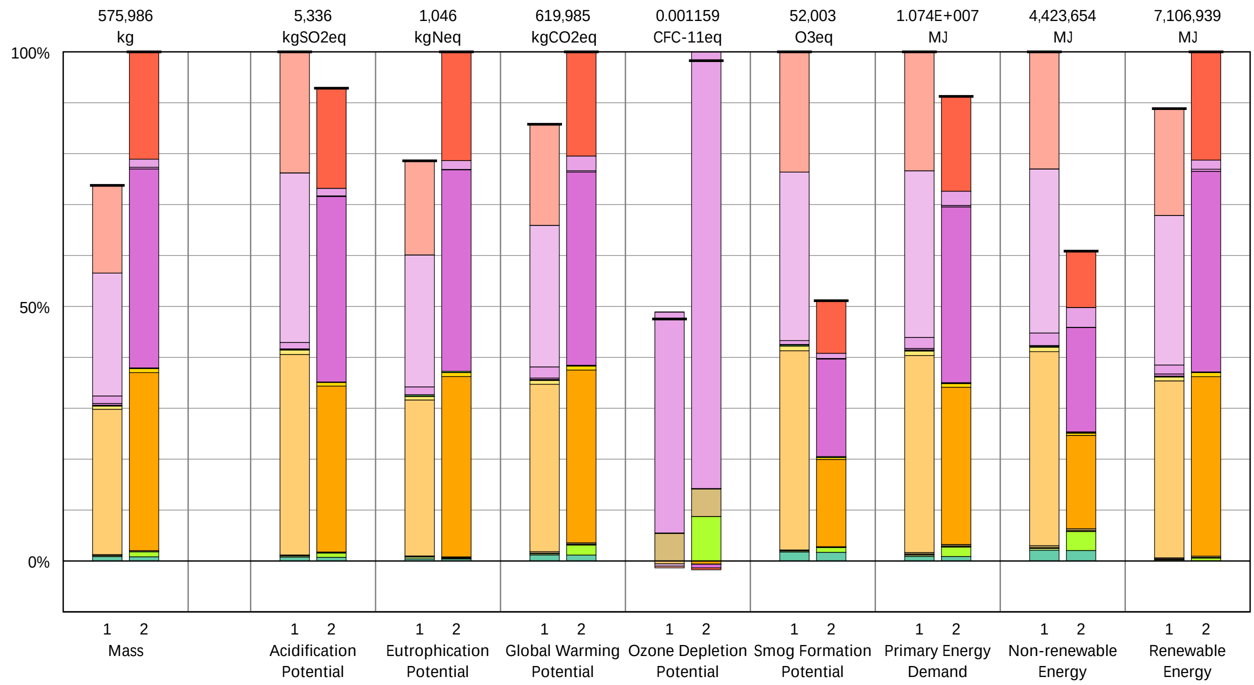
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1220mmx732mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1490mmx732mm
- Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1610mmx732mm
- Mass Bamboo Window Ope Center 910mm: Mass Bamboo Window Ope Center 910mm
- Mass Bamboo Window Ope Offset 910mm: Mass Bamboo Window Ope Offset 910mm

Walls

- Cross Laminated Timber Mass 100mm
- Cross Laminated Timber Mass 188mm
- Cross Laminated Timber Mass 300
- Generic Bamboo Mass 100
- Generic Bamboo Mass 188mm
- Generic Bamboo Mass 300

Results per Revit Category, itemized by Tally Entry



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Building Mass and LVB Panels (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- Glazing, triple pane IGU

Curtain Wall Mullions

- Aluminum, extrusion
- Flooring, bamboo plank

Doors

- Domestic softwood
- Door frame, wood
- Door, interior, wood, MDF core, flush
- Stainless steel, hardware

Floors

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Roofs

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Stairs and Railings

- Aluminum, extrusion
- Flooring, engineered wood plank

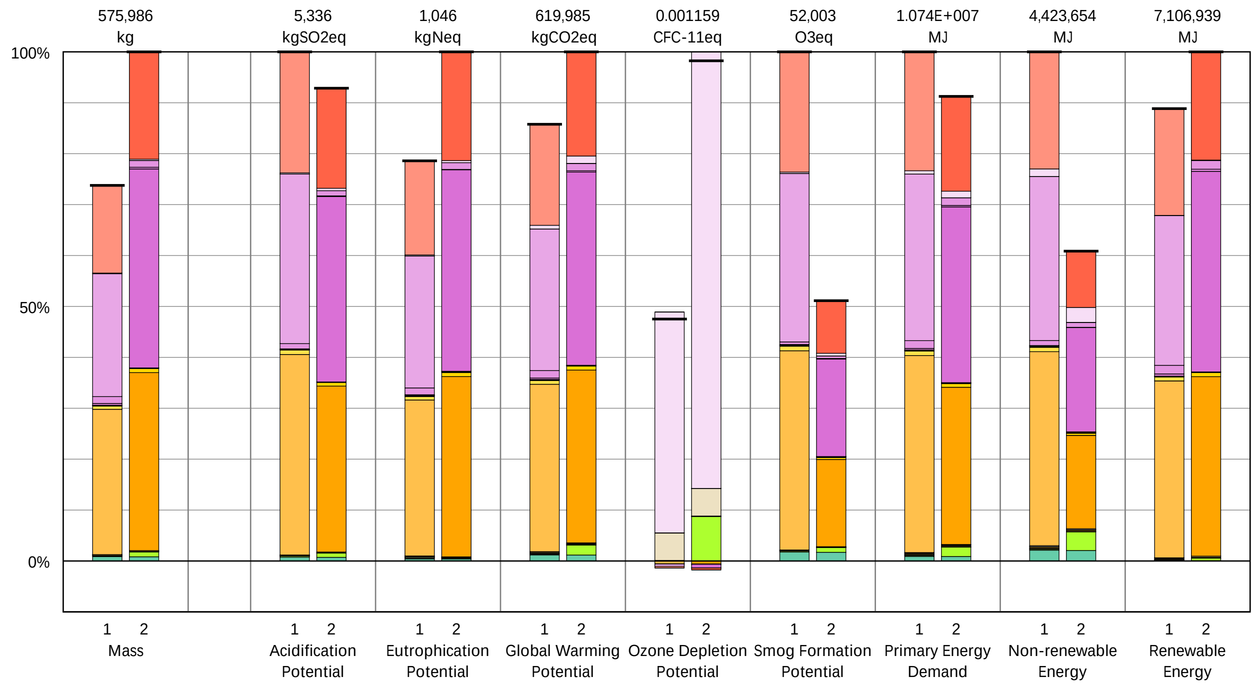
Structure

- Cross laminated timber (CrossLam / CLT)
- Domestic softwood
- Door, interior, wood, MDF core, flush
- Flooring, bamboo plank
- Stainless steel, hardware

Walls

- Cross laminated timber (CrossLam / CLT)
- Flooring, bamboo plank

Results per Revit Category, itemized by Material



Legend

Design Options

Option 1 - Bamboo LVB Hybrid Building Mass and LVB Panels (primary)

Option 2 - Cross Laminated Timber

Curtain Panels

- Glazing, triple, insulated (argon), low-E

Curtain Wall Mullions

- Aluminum, extruded
- Flooring, bamboo plank
- Polyurethane floor finish, water-based
- Powder coating, metal stock
- Urethane adhesive

Doors

- Domestic softwood, US
- Door frame, wood, no door
- Door, interior, wood, MDF Core, flush
- Hardware, stainless steel
- None
- Stainless steel, door hardware, lever lock, interior, residential

Floors

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Roofs

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Stairs and Railings

- Aluminum, extruded
- Interior grade plywood, US
- None
- Polyurethane floor finish, water-based
- Powder coating, metal stock
- Veneer, hardwood

Structure

- Cross laminated timber (CrossLam)
- Domestic softwood, US
- Door, interior, wood, MDF Core, flush
- Flooring, bamboo plank
- Hardware, stainless steel
- None
- Stainless steel, door hardware, lever lock, interior, residential

Walls

- Cross laminated timber (CrossLam)
- Flooring, bamboo plank
- None

Calculation Methodology

Studied objects

The LCA results in the report represent either an analysis of a single building, or a comparative analysis of two or more building design options. The single building may represent the complete architectural, structural, and finish systems of a building or a subset of those systems, and it may be used to compare the relative contributions of building systems to environmental impacts and for comparative study with one or more reference buildings. The comparison of design options may represent a full building in various stages of the design process, or they may represent multiple schemes of a full or partial building that are being compared to one another across a range of evaluation criteria.

Functional unit and reference flow

The functional unit of the analysis is the usable floor space of the building under study. For a design option comparison of a partial building, the functional unit is the complete set of building systems that performs a given function. The reference flow is the amount of material required to produce a building, or portion thereof, designed according to the given goal and scope of the assessment, over the full life of the building. If operational energy is included in the assessment the reference flow also includes the electrical and thermal energy consumed on site over the life of the building. It is the responsibility of the modeler to assure that reference buildings or design options are functionally equivalent in terms of scope, size, and relevant performance. The expected life of the building has a default value of 60 years and can be modified by the model author.

System boundaries and delimitations

The analysis accounts for the full cradle-to-grave life cycle of the design options studied, including material manufacturing, maintenance and replacement, and eventual end-of-life (disposal, incineration, and/or recycling), including the materials and energy used across all life cycle stages. Optionally, the operational energy of the building can be included within the scope.

Architectural materials and assemblies include all materials required for the product's manufacturing and use (including hardware, sealants, adhesives, coatings, and finishing, etc.) up to a 1% cut-off factor by mass with the exception of known materials that have high environmental impacts at low levels. In these cases, a 1% cut-off was implemented by impact.

Manufacturing includes cradle-to-gate manufacturing wherever possible. This includes raw material extraction and processing, intermediate transportation, and final manufacturing and assembly. Due to data limitations, however, some manufacturing steps have been excluded, such as the material and energy requirements for assembling doors and windows. The manufacturing scope is listed for each entry, detailing any specific inclusions or exclusions that fall outside of the cradle-to-gate scope.

Transportation of upstream raw materials or intermediate products to final manufacturing is generally included in the GaBi datasets utilized within this tool. Transportation requirements between the manufacturer and installation of the product, and at the end-of-life of the product, are excluded from this study.

Infrastructure (buildings and machinery) required for the manufacturing and assembly of building materials, as well as packaging materials, are not included and are considered outside the scope of assessment.

Maintenance and replacement encompasses the replacement of materials in accordance with the expected service life. This includes the end-of-life treatment of the existing products and cradle-to-gate manufacturing of the replacement products. The service life is specified separately for each product.

Operational energy treatment is based on the anticipated energy consumed at the building site over the lifetime of the building. Each energy dataset includes relevant upstream impacts associated with extraction of energy resources (e.g., coal, crude oil), refining, combustion, transmission, losses, and other associated factors. US electricity generation datasets are based on subregions from US EPA's eGRID2012 database v1.0, but adapted to account for imports and exports into these regions. These consumption mixes - unique to the GaBi databases - provide a more accurate reflection of impacts associated with electricity consumption.

End-of-life treatment is based on average US construction and demolition waste treatment methods and rates. This includes the relevant material collection rates for recycling, processing requirements for recycled materials, incineration rates, and landfilling rates. Along with processing requirements, the recycling of materials is modeled using an avoided burden approach, where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material. Incineration of materials includes credit for average US energy recovery rates. The impacts associated with landfilling are based on average material properties, such as plastic waste, biodegradable waste, or inert material. Specific end-of-life scenarios are detailed for each entry.

Data source and quality

Tally utilizes a custom designed LCA database that combines material attributes, assembly details, and engineering and architectural specifications with environmental impact data resulting from the collaboration between KieranTimberlake and PE INTERNATIONAL. LCA modeling was conducted in GaBi 6 using GaBi databases and in accordance with GaBi database and modeling principles.

Geography and date: The data used are intended to represent the US and the year 2013. Where representative data were unavailable, proxy data were used. The datasets used, their geographic region, and year of reference are listed for each entry. An effort was made to choose proxy datasets that are technologically consistent with the relevant entry.

Uncertainty in results can stem from both the data used and the application of the data. Data quality is judged by its precision (measured, calculated, or estimated), completeness (e.g., unreported emissions), consistency (degree of uniformity of the methodology applied on a study serving as a data source), and representativeness (geographical, temporal, and technological). The LCI data sets from the GaBi LCI databases have been used in LCA models worldwide in industrial and scientific applications, both as internal and critically reviewed and published studies. The uncertainty introduced by the use of any proxy data is reduced by using technologically, geographically, and/or temporally similar data. It is the responsibility of the modeler to apply the predefined material entries appropriately to the building under study.

Tally methodology is consistent with LCA standards ISO 14040-14044.

Glossary of LCA Terminology

Environmental Impact Categories

The following list provides a description of environmental impact categories reported according to the TRACI 2.1 characterization scheme. References: [Bare 2010, EPA 2012, Guinée 2001]

Acidification Potential (AP) — kg SO2 eq

A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule's capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline, and the deterioration of building materials.

Eutrophication Potential (EP) — kg N eq

Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which are nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems. In aquatic ecosystems increased biomass production may lead to depressed oxygen levels, because of the additional consumption of oxygen in biomass decomposition.

Global Warming Potential (GWP) — kg CO2 eq

A measure of greenhouse gas emissions, such as CO2 and methane. These emissions are causing an increase in the absorption of radiation emitted by the earth, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health, and material welfare.

Ozone Depletion Potential (ODP) — kg CFC-11 eq

A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth's surface with detrimental effects on humans and plants.

Smog Formation Potential (SFP) — kg O3 eq

Ground level ozone is created by various chemical reactions, which occur between nitrogen oxides (NOx) and volatile organic compounds (VOCs) in sunlight. Human health effects can result in a variety of respiratory issues including increasing symptoms of bronchitis, asthma, and emphysema. Permanent lung damage may result from prolonged exposure to ozone. Ecological impacts include damage to various ecosystems and crop damage. The primary sources of ozone precursors are motor vehicles, electric power utilities, and industrial facilities.

Primary Energy Demand (PED) — MJ (lower heating value)

A measure of the total amount of primary energy extracted from the earth. PED is expressed in energy demand from non-renewable resources (e.g. petroleum, natural gas, etc.) and energy demand from renewable resources (e.g. hydropower, wind energy, solar, etc.). Efficiencies in energy conversion (e.g. power, heat, steam, etc.) are taken into account.

LCA Metadata

NOTES

The following list provides a summary of all materials and energy inputs present in the selected study. Materials are listed in alphabetical order along with a list of all Revit families and Tally entries in which they occur and any notes and system boundaries accompanying their database entries. The mass given here refers to the full life-cycle mass of material, including manufacturing and replacement.

Aluminum, extruded — 5,621.2 kg

Used in the following Revit families:

1100mm	0.0 kg
Quad Corner Mullion: Quad Mullion 1	288.1 kg
Rectangular Mullion: 50 x 120mm	363.0 kg
Rectangular Mullion: 50 x 150mm	4,970.1 kg

Used in the following Tally entries:
Aluminum, extrusion

Description:
Extruded aluminum part

Life Cycle Inventory:
Aluminum, process energy

Manufacturing Scope:
Cradle to gate

End of Life Scope:
95% recovered (includes recycling, scrap preparation, and avoided burden credit)
5% landfilled (inert material)

Entry Source:
NA: Primary Aluminium Ingot AA (2011)
EU-27: Aluminium extrusion profile PE (2012)

Cross laminated timber (CrossLam) — 552,386.1 kg

Used in the following Revit families:

CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel	967.5 kg
CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel	1,589.3 kg
CLT Corner Panel: CLT Corner Panel Full Height NE-SE	1,752.0 kg
CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door	1,493.4 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	19,467.7 kg
CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1...	8,086.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm	459.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1006mmx2440mm	154.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1014mmx2440mm	1,396.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1022mmx2440mm	156.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1058mmx2440mm	303.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1078mmx2440mm	165.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1092mmx2440mm	334.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1100mmx2440mm	673.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1107mmx2440mm	169.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1115mmx2440mm	341.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1123mmx2440mm	1,031.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1127mmx2440mm	485.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1130mmx2440mm	810.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1145mmx2440mm	525.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1160mmx2440mm	355.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1192mmx2440mm	729.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1204mmx2440mm	184.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1212mmx2440mm	1,483.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1219mmx2440mm	746.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1220mmx2440mm	80,656.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1228mmx2440mm	187.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1232mmx2440mm	377.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1260mmx2440mm	192.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1274mmx2440mm	389.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1284mmx2440mm	368.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1286mmx2440mm	184.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1305mmx2440mm	187.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1334mmx2440mm	191.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1340mmx2440mm	820.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1352mmx2440mm	581.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1375mmx2440mm	210.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1383mmx2440mm	634.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1411mmx2440mm	2,375.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1434mmx2440mm	5,266.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1435mmx2440mm	219.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1442mmx2440mm	2,206.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1448mmx2440mm	443.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1455mmx2440mm	222.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 151mmx2440mm	86.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1531mmx2440mm	3,045.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1539mmx2440mm	2,355.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1542.8mmx2440mm	236.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm	1,423.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1578mmx2440mm	241.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1652mmx2440mm	474.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1702mmx2440mm	781.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1738mmx2440mm	266.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1740mmx2440mm	798.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1756mmx2440mm	537.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1764mmx2440mm	539.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1800mmx2440mm	275.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1850mmx2440mm	2,123.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1852mmx2440mm	283.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1860mmx2440mm	569.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1876mmx2440mm	287.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1878mmx2440mm	862.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm	1,152.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm 2	576.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1910mmx2440mm	1,753.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm	29.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1932mmx2440mm	591.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1941mmx2440mm	297.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1942mmx2440mm	3,863.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1944mmx2440mm	297.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1946mmx2440mm	595.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1950mmx2440mm	298.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1954mmx2440mm	2,392.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1973mmx2440mm	603.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1988mmx2440mm	912.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1991mmx2440mm	609.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2002.2mmx2440mm	306.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm	928.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2033mmx2440mm	622.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2038mmx2440mm	1,871.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2048mmx2440mm	313.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2049mmx2440mm	313.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2050mmx2440mm	313.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2056mmx2440mm	629.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2064mmx2440mm	315.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2111mmx2440mm	1,211.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2196mmx2440mm	336.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2372mmx2440mm	5,082.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2380mmx2440mm	728.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2440mmx2440mm	1,400.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2484mmx2440mm	2,280.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2492mmx2440mm	1,525.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2760mmx2440mm	396.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 290mmx2440mm	44.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 350mmx2440mm	200.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 462mmx2440mm	70.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 488mmx2440mm	74.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 535mmx2440mm	163.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 538mmx2440mm	164.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 543mmx2440mm	249.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 551mmx2440mm	84.3 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 556mmx2440mm	170.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 559mmx2440mm	85.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 616.2mmx2440mm	943.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 620mmx2440mm	94.9 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 640mmx2440mm	489.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 648mmx2440mm	99.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 670mmx2440mm	410.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 682mmx2440mm	195.7 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 696mmx2440mm	106.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 700mmx2440mm	428.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 710mmx2440mm	326.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 750mmx2440mm	5,165.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 772mmx2440mm	354.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 814mmx2440mm	124.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 822mmx2440mm	503.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 830mmx2440mm	3,302.5 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 842mmx2440mm	773.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 876.9mmx2440mm	268.4 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 877mmx2440mm	134.2 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 896mmx2440mm	137.1 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 930mmx2440mm	284.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 950mmx2440mm	1,744.6 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 958mmx2440mm	439.8 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 978mmx2440mm	140.3 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1220mmx732mm	4,256.9 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1320mmx732mm	56.8 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1490mmx732mm	547.3 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1530mmx732mm	65.9 kg

LCA Metadata (continued)

CLT Full Panel 1220mmx2440mm: CLT Half Panel 1610mmx732mm	517.4 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1990mmx732mm	85.7 kg
CLT Timber	201,344.7 kg
CLT Window Ope Center 910mm: CLT Window Ope Center 910mm	11,589.9 kg
CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm	1,617.2 kg
CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus ...	1,208.3 kg
Cross Laminated Timber CLT	4,582.3 kg
Cross Laminated Timber Mass 100mm	239.0 kg
Cross Laminated Timber Mass 188mm	2,241.5 kg
Cross Laminated Timber Mass 300	118,945.6 kg

Used in the following Tally entries:
Cross laminated timber (CrossLam / CLT)

Description:
PROXIED by LVL

Life Cycle Inventory:
43% PNW
57% SE
Proxied by LVL

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
US: Laminated veneer lumber, at plant, US PNW USLCI/PE (2009)
US: Laminated veneer lumber, at plant, US SE USLCI/PE (2009)

Domestic softwood, US — 4,275.3 kg

Used in the following Revit families:

24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L...	821.4 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	1,973.6 kg
IntSgl (7): 1010 x 2110mm	74.4 kg
IntSgl (7): 810 x 2110mm	128.8 kg
IntSgl (7): 910 x 2110mm	102.2 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	1,175.0 kg

Used in the following Tally entries:
Domestic softwood

Description:
Dimensional lumber, sawn, planed, dried and cut for standard framing or planking

Life Cycle Inventory:
38% PNW
62% SE
Dimensional lumber

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Surfaced dried lumber, at planer mill, PNW USLCI/PE (2009)
US: Surfaced dried lumber, at planer mill, SE USLCI/PE (2009)

Door frame, wood, no door — 279.1 kg

Used in the following Revit families:

IntSgl (7): 1010 x 2110mm	68.0 kg
IntSgl (7): 810 x 2110mm	117.7 kg
IntSgl (7): 910 x 2110mm	93.4 kg

Used in the following Tally entries:
Door frame, wood

Description:
Wood door frame

Life Cycle Inventory:
Dimensional lumber

Manufacturing Scope:
Cradle to gate, excludes hardware, jamnb, casing, sealant

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
DE: Wooden frame (EN15804 A1-A3) PE (2012)

Door, interior, wood, MDF Core, flush — 17,405.3 kg

Used in the following Revit families:

24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L...	3,200.2 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	7,689.4 kg
IntSgl (7): 1010 x 2110mm	523.0 kg
IntSgl (7): 810 x 2110mm	754.9 kg
IntSgl (7): 910 x 2110mm	659.7 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	4,578.1 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Interior flush wood door with MDF core

Life Cycle Inventory:
12.2 kg/m² Wood, 0.052 m3/m3 MDF

Manufacturing Scope:
Cradle to gate, excludes assembly, frame, hardware, and adhesives

End of Life Scope:
14.5% wood products recovered (credited as avoided burden)
22% wood products incinerated with energy recovery
63.5% wood products landfilled (wood product waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)
DE: Wood fibre board PE (2012)

Flooring, bamboo plank — 407,182.8 kg

Used in the following Revit families:

24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	1.3 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	5.7 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	2.0 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	4.5 kg
24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Pan...	1,664.4 kg
24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Pan...	15.0 kg
24mm LVB Corner Panel Half Adaptable 2440mm x Length x Length: 24mm...	529.5 kg
24mm LVB Door Ope Panel 2440x1220x128 NO Door A: 24mm LVB Door Ope ...	410.1 kg
24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L...	2,271.5 kg
24mm LVB Level 8 Window 300 x 910mm Offset: 24mm LVB Level 8 Window...	71.3 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 120	19.8 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 122	10.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 132	10.6 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 147	11.4 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 151	46.5 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 160	12.1 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 191	55.2 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 214	30.1 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 221	30.9 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 228	31.6 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 231	32.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 241	16.5 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 248	16.9 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 255	51.9 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 260	35.1 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 310	182.5 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 320	83.3 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 330.2	42.8 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 331	214.3 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 334	108.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 342	176.2 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 355	68.2 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 358	68.7 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 432	26.9 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 72	14.6 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1014m...	242.6 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1058m...	62.9 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1100m...	1,430.9 kg

LCA Metadata (continued)

24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1130m…	199.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1152m…	406.2 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1160m…	204.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1192m…	139.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1212m…	212.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1216m…	71.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1220m…	10,144.9 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x520mm…	35.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x538mm…	72.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x554mm…	74.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616.2…	161.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616mm…	40.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x620mm…	40.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x630mm…	328.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x662mm…	85.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x666mm…	85.8 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x670mm…	86.2 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x682mm…	43.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x698mm…	44.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x702mm…	44.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x710mm…	180.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x712mm…	90.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x722mm…	365.9 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x730mm…	46.1 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x734mm…	278.1 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x750mm…	990.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x772mm…	193.2 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x776mm…	48.5 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x821mm…	254.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x826mm…	102.1 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x830mm…	1,230.1 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x836mm…	51.6 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x842mm…	259.3 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x891mm…	108.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x900mm…	109.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x930mm…	56.4 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x950mm…	401.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x976mm…	58.7 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x978mm…	58.8 kg
24mm LVB Window 910mm Offset 1220 x 2440mm: 24mm LVB Window 910mm…	1,545.1 kg
24mm Window 910mm Center 1220x2440mm: 24mm Window 910mm Center 1220…	1,572.2 kg
Bamboo LVB	3,740.6 kg
Generic Bamboo Mass 100	195.1 kg
Generic Bamboo Mass 188mm	1,829.8 kg
Generic Bamboo Mass 300	97,176.2 kg
LVB Bamboo Floor	164,371.7 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NE-SE Corner Panel	287.2 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NW-SW Corner Panel	763.2 kg
Mass Bamboo Corner Panel: Mass Bamboo Corner Panel Full Height NE-SE	1,430.2 kg
Mass Bamboo Door Ope 900mm No Door: Mass Bamboo Door Ope 900mm No Door	443.3 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	5,707.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1000mm…	374.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1014mm…	633.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1022mm…	255.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1036mm…	121.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1078mm…	134.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1100mm…	1,099.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1130mm…	132.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1145mm…	572.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1152mm…	1,439.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1160mm…	144.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1192mm…	297.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1212mm…	302.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1220mm…	47,400.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1286mm…	160.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1340mm…	167.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1352mm…	158.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1383mm…	518.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1411mm…	352.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1434mm…	3,403.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1435mm…	179.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1448mm…	542.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1531mm…	382.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1539mm…	1,153.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1542.8…	192.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1550.2…	1,162.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1554mm…	970.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1562mm…	390.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1652mm…	193.5 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1702mm…	637.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1738mm…	217.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1740mm…	217.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1756mm…	438.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1764mm…	440.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1792mm…	220.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mm…	470.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1942mm…	1,455.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1954mm…	976.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 282mmx…	35.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 342mmx…	80.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 535mmx…	267.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 543mmx…	67.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 551mmx…	137.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 616.2m…	461.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 640mmx…	719.6 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 666mmx…	83.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 670mmx…	167.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 682mmx…	79.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 690mmx…	172.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 698mmx…	348.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 700mmx…	174.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 732mmx…	91.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 750mmx…	2,342.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 760mmx…	189.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 768mmx…	95.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 772mmx…	192.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 776mmx…	387.8 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 803mmx…	301.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 818mmx…	613.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 821mmx…	307.7 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 826mmx…	206.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 829mmx…	207.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 830mmx…	1,970.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 832mmx…	207.9 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 836mmx…	104.4 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 842mmx…	736.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 877mmx…	219.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 891mmx…	111.3 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 922mmx…	115.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 950mmx…	1,068.1 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1220mm…	457.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1490mm…	279.2 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1610mm…	301.7 kg
Mass Bamboo Window Ope Center 910mm: Mass Bamboo Window Ope Center…	6,270.8 kg
Mass Bamboo Window Ope Offset 910mm: Mass Bamboo Window Ope Offset…	5,280.6 kg
Quad Corner Mullion: Quad Mullion Bamboo	43.2 kg
Rectangular Mullion: 50 x 120mm Bamboo	53.7 kg
Rectangular Mullion: 50 x 150mm Bamboo	742.6 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Bamboo plank flooring

Life Cycle Inventory:
90% Bamboo, 10% phenol formaldehyde

Manufacturing Scope:
Cradle to gate for raw material only, includes transportation from China and estimate for material processing neglects materials for installation

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (wood product waste)

Entry Source:
CN: Bamboo (estimation) PE (2012)
GLO: Bulk commodity carrier PE (2012)
US: Heavy fuel oil at refinery (0.3wt.% S) PE (2010)
CN: Electricity grid mix PE (2010)
DE: Phenol formaldehyde resin PE (2012)

Glazing, triple, insulated (argon), low-E	9,630.3 kg

Used in the following Revit families:

System Panel: Glazed	9,630.3 kg

Used in the following Tally entries:
Glazing, triple pane IGU

Description:
Glazing, triple, insulated (argon filled), 1/8" float glass, low-E, inclusive of argon gas fill, sealant, and spacers

LCA Metadata (continued)

Life Cycle Inventory:
32.4 kg/m² glass
Argon filled, 0.15 kg/m² low-e coating

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Insulation glass compound (3 panes) PE (2012)

Hardware, stainless steel 9.1 kg

Used in the following Revit families:

24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L...	0.3 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	0.6 kg
IntSgl (7): 1010 x 2110mm	2.1 kg
IntSgl (7): 810 x 2110mm	3.1 kg
IntSgl (7): 910 x 2110mm	2.7 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	0.4 kg

Used in the following Tally entries:
Stainless steel, hardware

Description:
Finished, cast stainless steel entry applicable for door, window or other accessory hardware

Life Cycle Inventory:
Stainless steel

Manufacturing Scope:
Cradle to gate

End of Life Scope:
98% recovered (product has 58.1% scrap input while remainder is processed and credited as avoided burden)
2% landfilled (inert material)

Entry Source:
RER: Stainless steel Quarto plate (304) Eurofer (2008)
DE: Steel cast part machining PE (2012)
US: Electricity grid mix PE (2010)
RER: Stainless steel flat product (304) - value of scrap Eurofer (2008)

Interior grade plywood, US 1,023.1 kg

Used in the following Revit families:

Stair	1,023.1 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Plywood, unfinished

Life Cycle Inventory:
33% PNW
67% SE
Plywood
Proxied by exterior grade plywood

Manufacturing Scope:
Cradle to gate

End of Life Scope:
14.5% recovered (credited as avoided burden)
22% incinerated with energy recovery
63.5% landfilled (untreated wood waste)

Entry Source:
US: Plywood, at plywood plant, PNW USLCI/PE (2009)
US: Plywood, at plywood plant, SE USLCI/PE (2009)

None 0.0 kg

Used in the following Revit families:

24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	0.0 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	0.0 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	0.0 kg
24 mm LVB Balcony Half Panel Single: 24 mm LVB Balcony Half Panel S...	0.0 kg
24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Pan...	0.0 kg
24mm LVB Balcony Half Panel 732 x 1220 A: 24mm LVB Balcony Half Pan...	0.0 kg
24mm LVB Corner Panel Half Adaptable 2440mm x Length x Length: 24mm...	0.0 kg
24mm LVB Door Ope Panel 2440x1220x128 NO Door A: 24mm LVB Door Ope ...	0.0 kg
24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L...	0.0 kg
24mm LVB Level 8 Window 300 x 910mm Offset: 24mm LVB Level 8 Window...	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 120	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 122	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 132	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 147	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 151	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 160	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 191	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 214	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 221	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 228	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 231	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 241	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 248	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 255	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 260	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 310	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 320	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 330.2	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 331	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 334	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 342	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 355	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 358	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 432	0.0 kg
24mm LVB Single Box 128 x Width: 24mm LVB Single Box 128 x 72	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1014m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1058m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1100m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1130m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1152m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1160m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1192m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1212m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1216m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x1220m...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x520mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x538mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x554mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616.2...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x616mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x620mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x630mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x662mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x666mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x670mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x682mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x698mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x702mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x710mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x712mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x722mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x730mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x734mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x750mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x772mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x776mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x821mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x826mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x830mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x836mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x842mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x891mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x900mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x930mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x950mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x976mm...	0.0 kg
24mm LVB Standard 2440x1220mm Panel A: 24mm LVB Standard 2440x978mm...	0.0 kg
24mm LVB Window 910mm Offset 1220 x 2440mm: 24mm LVB Window 910mm O...	0.0 kg
24mm Window 910mm Center 1220x2440mm: 24mm Window 910mm Center 1220...	0.0 kg
Bamboo LVB	0.0 kg
CLT Corner Panel: CLT Balcony Half NE-SE Corner Panel	0.0 kg

LCA Metadata (continued)

CLT Corner Panel: CLT Balcony Half NW-SW Corner Panel	0.0 kg
CLT Corner Panel: CLT Corner Panel Full Height NE-SE	0.0 kg
CLT Door Ope 900mm No Door: CLT Door Ope 900mm No Door	0.0 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	0.0 kg
CLT Double Window Ope Center 1820mm: CLT Double Window Ope Center 1…	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1000mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1006mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1014mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1022mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1058mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1078mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1092mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1100mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1107mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1115mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1123mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1127mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1130mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1145mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1160mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1192mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1204mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1212mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1219mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1220mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1228mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1232mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1260mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1274mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1284mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1286mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1305mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1334mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1340mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1352mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1375mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1383mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1411mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1434mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1435mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1442mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1448mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1455mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 151mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1531mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1539mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1542.8mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1550.2mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1578mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1652mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1702mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1738mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1740mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1756mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1764mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1800mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1850mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1852mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1860mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1876mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1878mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1882mmx2440mm 2	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1910mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 191mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1932mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1941mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1942mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1944mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1946mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1950mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1954mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1973mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1988mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 1991mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2002.2mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2023mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2033mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2038mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2048mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2049mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2050mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2056mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2064mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2111mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2196mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2372mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2380mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2440mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2484mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2492mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 2760mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 290mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 350mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 462mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 488mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 535mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 538mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 543mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 551mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 556mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 559mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 616.2mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 620mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 640mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 648mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 670mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 682mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 696mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 700mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 710mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 750mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 772mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 814mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 822mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 830mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 842mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 876.9mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 877mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 896mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 930mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 950mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 958mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Full Panel 978mmx2440mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1220mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1320mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1490mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1530mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1610mmx732mm	0.0 kg
CLT Full Panel 1220mmx2440mm: CLT Half Panel 1990mmx732mm	0.0 kg
CLT Timber	0.0 kg
CLT Window Ope Center 910mm: CLT Window Ope Center 910mm	0.0 kg
CLT Window Ope Offset 910mm: CLT Window Ope Offset 910mm	0.0 kg
CLT Window Ope Single Plus Half 1260mm: CLT Window Ope Single Plus …	0.0 kg
Cross Laminated Timber CLT	0.0 kg
Cross Laminated Timber Mass 100mm	0.0 kg
Cross Laminated Timber Mass 188mm	0.0 kg
Cross Laminated Timber Mass 300	0.0 kg
Generic Bamboo Mass 100	0.0 kg
Generic Bamboo Mass 188mm	0.0 kg
Generic Bamboo Mass 300	0.0 kg
IntSgl (7): 1010 x 2110mm	0.0 kg
IntSgl (7): 810 x 2110mm	0.0 kg
IntSgl (7): 910 x 2110mm	0.0 kg
LVB Bamboo Floor	0.0 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NE-SE Corner Panel	0.0 kg
Mass Bamboo Corner Panel: Mass Bamboo Balcony Half NW-SW Corner Panel	0.0 kg
Mass Bamboo Corner Panel: Mass Bamboo Corner Panel Full Height NE-SE	0.0 kg
Mass Bamboo Door Ope 900mm No Door: Mass Bamboo Door Ope 900mm No Door	0.0 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1000mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1014mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1022mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1036mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1078mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1100mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1130mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1145mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1152mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1160mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1192mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1212mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1220mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1286mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1340mm…	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1352mm…	0.0 kg

LCA Metadata (continued)

Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1383mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1411mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1434mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1435mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1448mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1531mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1539mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1542.8...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1550.2...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1554mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1562mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1652mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1702mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1738mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1740mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1756mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1764mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1792mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1882mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1942mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 1954mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 282mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 342mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 535mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 543mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 551mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 616.2m...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 640mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 666mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 670mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 682mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 690mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 698mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 700mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 732mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 750mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 760mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 768mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 772mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 776mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 803mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 818mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 821mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 826mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 829mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 830mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 832mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 836mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 842mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 877mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 891mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 922mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Full Panel 950mmx...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1220mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1490mm...	0.0 kg
Mass Bamboo Full Panel 1220mmx2440mm: Mass Bamboo Half Panel 1610mm...	0.0 kg
Mass Bamboo Window Ope Center 910mm: Mass Bamboo Window Ope Center ..	0.0 kg
Mass Bamboo Window Ope Offset 910mm: Mass Bamboo Window Ope Offset ...	0.0 kg
Stair	0.0 kg

Used in the following Tally entries:
Cross laminated timber (CrossLam / CLT)
Domestic softwood
Door, interior, wood, MDF core, flush
Flooring, bamboo plank
Flooring, engineered wood plank

Description:
This entry is a placeholder, for use in cases when there is "no" finish, or "no added material designated.

Manufacturing Scope:
NA

Entry Source:
None

Polyurethane floor finish, water-based — 203.7 kg

Used in the following Revit families:

Quad Corner Mullion: Quad Mullion Bamboo	0.0 kg
Rectangular Mullion: 50 x 120mm Bamboo	0.0 kg
Rectangular Mullion: 50 x 150mm Bamboo	0.3 kg
Stair	203.3 kg

Used in the following Tally entries:
Flooring, bamboo plank
Flooring, engineered wood plank

Description:
Water-based polyurethane wood stain, inclusive of catalyst

Life Cycle Inventory:
97.7% stain (50% water, 35% polyurethane dispersions, 5% dipropylene glycol dimethyl ether, 5% tri-butoxyethyl phosphate, 5% dipropylene glycol methyl ether), 2.3% catalyst (75% polyfunctional aziridine, 25% 2-propoxyethanol)
24.5% NMVOC emissions during application

Manufacturing Scope:
Cradle to gate, including emissions during application

End of Life Scope:
26.7% solids to landfill (plastic waste)

Entry Source:
DE: Ethylene glycol butyl ether PE (2012)
US: Epichlorohydrin (by product calcium chloride, hydrochloric acid) PE (2012)
DE: Propylenglycolmonomethylether (Methoxypropanol) PGME PE (2012)
US: Tap water from groundwater PE (2012)
DE: Polyurethane (copolymer-component) (estimation from TPU adhesive) PE (2012)
US: Electricity grid mix PE (2010)

Powder coating, metal stock — 90.2 kg

Used in the following Revit families:

1100mm	72.5 kg
Quad Corner Mullion: Quad Mullion 1	0.5 kg
Rectangular Mullion: 50 x 120mm	1.2 kg
Rectangular Mullion: 50 x 150mm	16.0 kg

Used in the following Tally entries:
Aluminum, extrusion

Description:
Powder coating, for metal stock

Manufacturing Scope:
Cradle to gate, including application

End of Life Scope:
100% to landfill (inert waste)

Entry Source:
DE: Application top coat powder (aluminium) PE (2012)
DE: Coating powder (industry
outside
red) PE (2012)

Stainless steel, door hardware, lever lock, interior, residential — 2,311.1 kg

Used in the following Revit families:

24mm LVB Door Ope Panel 2440x1220x128 w-900x2110 door ope A: 24mm L..	294.7 kg
CLT Door Ope 900mm: CLT Door Ope 900mm	1,416.3 kg
IntSgl (7): 1010 x 2110mm	48.2 kg
IntSgl (7): 810 x 2110mm	69.5 kg
IntSgl (7): 910 x 2110mm	60.8 kg
Mass Bamboo Door Ope 900mm: Mass Bamboo Door Ope 900mm	421.6 kg

Used in the following Tally entries:
Door, interior, wood, MDF core, flush

Description:
Stainless steel door fitting (hinges and lockset) for use on residential interior door assemblies.

Life Cycle Inventory:
Door hinges 0.622 kg/part, Battalion Lever Lockset, Light Duty, Privacy 0.70 kg/part

Manufacturing Scope:
Cradle to gate, including disposal of packaging.

LCA Metadata (continued)

End of Life Scope:
90% collection rate
remaining 10% deposited in the LCA model without recycling
material recycling efficiency dependant on the metal (89% steel, 90.2% aluminum, stainless steel 83%, zinc 91%, brass 94%)
Plastic components incinerated resulting in credits for electricity and thermal energy

Entry Source:
DE: Fitting stainless steel - FSB (2009)

Urethane adhesive	190.3 kg
Used in the following Revit families:	
Quad Corner Mullion: Quad Mullion Bamboo	5.1 kg
Rectangular Mullion: 50 x 120mm Bamboo	13.3 kg
Rectangular Mullion: 50 x 150mm Bamboo	172.0 kg

Used in the following Tally entries:
Flooring, bamboo plank

Description:
Urethane adhesive for use with flooring and wall coverings.

Life Cycle Inventory:
50% limestone, 13% lime, 30% polyurethane, 1.5% stearic acid, 5% Methylene bis(phenylisocyanate) (MDI)
1.3% NMVOC emissions

Manufacturing Scope:
Cradle to gate, plus emissions during application

End of Life Scope:
98.7% solids to landfill (plastic waste)

Entry Source:
US: Limestone flour (5mm) PE (2012)
DE: Polyurethane (copolymer-component) (estimation from TPU adhesive) PE (2012)
US: Lime (CaO) calcination PE (2012)
US: Methylene diisocyanate (MDI) PE (2012)
DE: Stearic acid PE (2012)
US: Electricity grid mix PE (2010)

Veneer, hardwood	307.1 kg
Used in the following Revit families:	
Stair	307.1 kg

Used in the following Tally entries:
Flooring, engineered wood plank

Description:
Hardwood veneer

Life Cycle Inventory:
43% PNW
57% SE
veneer

Manufacturing Scope:
Cradle to gate

End of Life Scope:
100% landfilled (biodegradable waste)

Entry Source:
US: Dry veneer, at plywood plant, PNW USLCI/PE (2009)
US: Dry veneer, at plywood plant, SE USLCI/PE (2009)